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THE ECONOMIC DEPTH FOR CANALS OF LARGE TRAFFIC.

BY JOSEPH MAYER, M. Am. Soc. C. E.

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WITH DISCUSSION.

There is a strong desire in some of the large cities along the Great Lakes to become seaports, and a widespread belief in the possibility of its accomplishment. The survey of a ship-canal 28 ft. deep from the lakes to the ocean, at present under way, is proof that this desire has had sufficient force to induce favorable action in Congress.

The Northwestern States are vitally interested in reducing freight rates to Europe, even more than in reducing rates to home markets, since the home price of produce which is exported in considerable quantities is equal to the price in the principal foreign markets, less the cost of reaching them. In view of the fact that Montreal will soon have a canal 14 ft. deep, with locks 45 ft. wide and 270 ft. long, connecting it with the West, New York has made an effort to improve its canals by beginning the work of deepening them to 9 ft. The unexpected cost of this work will at least cause delay, and has again brought up the question: "What should be done?"

The most valuable information helping to answer this question is contained in a report by Major Symons, M. Am. Soc. C. E., to the Chief of Engineers, U. S. A., on a canal between the Great Lakes and New York, capable of accommodating the tonnage of the lakes. Major Symons is in favor of a barge-canal of about 12 ft. depth; he believes that a ship-canal of 24 ft. depth or more would not cause a sufficient saving in cost of transportation over a barge-canal of 12 ft. depth to pay a reasonable return on the additional expense, even with an estimated tonnage of 24 000 000 a year passing through it.

The present cost of transportation by water for a bushel of wheat from Chicago to Liverpool is, according to Major Symons:

Chicago to Buffalo.....	1.37 cents.
Transfer charge, Buffalo.....	1.16 "
Buffalo to New York	2.65 "
Transfer charge, New York.....	1.50 "
New York to Liverpool.....	5.43 "
Chicago to Liverpool.....	12.11 "

Of the rate of 5.43 cents from New York to Liverpool, the vessel owner pays for trimming 0.2 cent a bushel, which leaves him 5.23 cents a bushel. The items given as transfer charges in Buffalo and New York are only a part of the cost caused by these transfers. A ship loading in Chicago and unloading in Liverpool would, in comparison with the present ship between Chicago and Buffalo, the canal boats between Buffalo and New York, and the ship between New York and Liverpool, save all the time spent for transfers in Buffalo and New York. It would therefore save half the time spent in port by the lake ship and ocean vessel and the whole time spent in port by the canal-boat.

The canal-boat spends twelve days out of thirty of the active season in port, and about one-third of its expenses are incurred during this time. The ocean vessel and lake vessel spend, respectively, say, 0.3 and 0.4 of their time in port, and about one-quarter and one-third of their expenses are incurred while there. Therefore, one-sixth of the cost from Chicago to Buffalo, one-third of the cost from Buffalo to New York, and one-eighth of the cost from New York to Liverpool, are chargeable to costs of transfer in Buffalo and New York.

The present costs due to transfers in Buffalo and New York are therefore as follows in cents per bushel of wheat:

Transfer cost, Buffalo.....($\frac{1}{3}$ of 1.37) + 1.16 + ($\frac{1}{3}$ of 2.65) = 1.83	
Transfer cost, New York...($\frac{1}{3}$ of 2.65) + 1.70 + ($\frac{1}{3}$ of 5.23) = 2.79	
Total costs of transfer, Buffalo and New York	4.62

The revised estimate, in detail, of present costs Chicago to Liverpool, in cents per bushel of wheat, is therefore as follows:

Chicago to Buffalo.	1.14	cents.
Transfer in Buffalo.	1.83	"
Buffalo to New York.....	1.77	"
Transfer in New York.....	2.79	"
New York to Liverpool.....	4.58	"
Total, Chicago to Liverpool,.....	12.11	"

The cost of transfers, of 4.62 cents per bushel, or \$1.54 per ton, equal to 38% of the total cost, would be saved by a ship-canal allowing ocean steamers to pass to the lakes, unless it should prove to be more expensive to transport freight from Chicago to New York in ocean steamers than the present cost of transport from Chicago to Buffalo and Buffalo to New York, which is $1.14 + 1.77 = 2.91$ cents per bushel.

Major Symons gives an estimate of the cost of transport from Chicago to New York in a lake steamer of 16-ft. draft, through a 24-ft. canal, from Buffalo to New York, and from this can be obtained an idea of the cost in an ocean steamer from Chicago to New York. A lake steamer is better adapted to transport on the lakes than an ocean steamer. The fact that freight rates per ton-mile are about the same on the lakes and the ocean, however, shows that the advantage which an ocean steamer has of running throughout the whole year nearly balances the disadvantages arising from its design, and the cost from Chicago to Buffalo in an ocean steamer running in 28-ft. channels would be about the same as the cost in the present lake steamers.

On a ship-canal 28 ft. deep, from Buffalo to New York, an ocean steamer could do business about as cheaply as a lake steamer of 16-ft. draft, because here, also, their advantages and disadvantages would about balance one another. The cost of transport from Chicago to New York in an ocean steamer would therefore be the same as in a

lake steamer. The table on page 284, which is obtained, by corrections presently to be explained, from Major Symons' Table No. 32, gives this cost of transport from Chicago to New York by a lake vessel of 16-ft. draft as 2.92 cents per bushel. This is 0.01 cent more than the present cost on lake and canal. The total saving in the cost of transportation of a bushel of wheat from Chicago to Liverpool attainable by providing a 28-ft. channel is therefore $4.62 - 0.01 = 4.61$ cents per bushel or \$1.54 per ton.

There is a very serious error in Major Symons' estimate of the cost of transportation of wheat from Chicago to New York by a steamer of either 16 or 20-ft. draft, through a canal 24 ft. deep between Buffalo and New York. He obtains the cost by adding to the present freight-rates on the lakes from Chicago to Buffalo his calculated cost from Buffalo to New York. It must be remembered that the freight-rate from Chicago to Buffalo allows for the loss of time caused by loading and unloading in Buffalo. If the steamer went through Buffalo both ways without loading and unloading, this time would be saved. It is reasonable to assume, that if a ship-canal existed, facilities for loading and unloading would be provided in New York at least as good as those existing in Buffalo. The only additional time required for the round trip from Chicago to New York and back, instead of to Buffalo and back, would be the time required for going and coming from Buffalo to New York.

This time with an average speed in canal and canalized river of 4 miles, and a speed of 13 miles in lake and river, would be 7 days 12 hours, and not 22 days as Major Symons estimates. If it is remembered that the running cost of the steamer per day would be the same during these 7 days 12 hours, with the exception of the cost for fuel, oil, and waste, and possibly of insurance on wheat, as the daily cost on the assumed 22 days, it is easy to obtain the additional cost of going from Chicago to New York and return, instead of from Chicago to Buffalo and return. For this purpose Table No. 25 of Major Symons' report is here introduced: Ship-canal, Buffalo to New York, Oswego route, steel lake-freighter of largest type, drawing 20 ft., carrying 7 000 tons of wheat down. Wheat transported down annually 70 000 tons, return up one-third load miscellaneous freight, aggregating 23 333 tons annually; steamer value \$250 000; value per ton of carrying capacity at 20-ft. draft, \$35.71.

SEASON'S EXPENSES.

1. Wages and subsistence.....	\$9 314.25
2. Fuel, oil, waste, etc.....	11 675.00
3. Ordinary repairs.....	1 800.00
4. Insurance on steamer.....	8 750.00
5. Insurance on wheat.....	6 125.00
4. Interest on cost, 6%.....	15 000.00
7. Deterioration, etc., 6%	15 000.00
8. Miscellaneous small expenses.....	750.00
Total	<u>\$68 414.25</u>

If insurance on wheat is assumed to be the same per trip, whatever the time required, and if the same is true of fuel, oil and waste, both unfavorable assumptions for ship transportation, the cost per day of items 1, 3, 4, 6, 7, 8 is obtained by dividing the items given by 220, the number of days the vessel is assumed to be in commission. The cost per trip of items 2 and 5 is obtained by dividing the above amounts by 10, the number of trips assumed. This gives the total cost for $7\frac{1}{2}$ days as \$35 063.

The freight carried per round trip is equivalent to 300 000 bushels of wheat. The cost per bushel is therefore 1.17 cents instead of 2.28 cents, as given by Mayor Symons.

For a steamer of 16-ft. draft Mayor Symons' figure is 2.81 cents, and the corrected figure is 1.41 cents. These corrected figures of 1.17 and 1.41 cents are the costs from Buffalo to New York, because in this calculation the whole cost to the steamer caused by delays in port has been charged to the cost from Chicago to Buffalo. About 0.46 cent per bushel ought to be subtracted from the rate from Chicago to Buffalo for costs in port, caused by transfers. For a steamer of 16-ft. draft the cost from Chicago to New York ought therefore to be divided as follows:

Cost in Chicago for transfer.....	0.23 cent per bushel.
Chicago to Buffalo for transport.....	0.91 " "
Buffalo to New York for transport.....	1.41 " "
Cost in New York for transfer.....	0.23 " "
Total	<u>2.78 cents "</u>

To this ought to be added 0.14 cent for profit from Buffalo to New York, giving a total of 2.92 cents per bushel.

In the determination of the most economical method of transportation between the Great Lakes and Europe there are these alternatives to be considered:

First.—Lake steamers on the lakes, barges on the canals and river and ocean steamers from New York. This method offers the cheapest transport on lakes, canals and ocean. It requires only a cheap canal of moderate water-prism between Buffalo and Albany. It is, however, subject to heavy costs of transfer at Buffalo and New York. The delays caused by transfers make this the slowest method. It probably justifies a canal 12 ft. deep.

Second.—Barges on the lakes, canals and near sea coasts; ocean steamers for distant sea coasts and foreign trade. This method avoids all transfer in Buffalo, and a large part of it in New York. It gives fairly cheap transport on the lakes, canals, and along the sea coasts, but it is subject to heavy costs for transfer in New York on a part of the traffic. It probably requires a canal 16 to 18 ft. deep to make it most economical.

Third.—Ocean steamers for through business between the West and foreign countries or distant sea coasts; barges or lake steamers between the West and the East. This avoids all transfers, gives cheap transportation on the lakes and ocean, but rather dear transportation on canals for through business between the West and Europe. For business between the West and the East it gives the best accommodation, allowing a larger speed for barges and lake steamers. It is the fastest route for all traffic; but it needs not only enormously expensive canals, but also the deepening of lake channels and harbors.

It is evident from the above, that for determining which is the best method the following data have to be obtained:

- (a) Cost of canals between Buffalo and New York of, say, 12, 18, 24 and 28 ft. depth.
- (b) Cost of deepening lake channels and harbors to various depths.
- (c) Cost of transportation in ocean vessels of various draft from 20 to 26 ft. on the ocean or lakes, and in canals and rivers.
- (d) Cost of transportation in barges and lake vessels of various draft in canals and rivers of different size, and on the lakes and sea coasts.
- (e) Cost of transfer in New York and Buffalo and methods of improving the same.
- (f) Probable amount of traffic through canals of various depths and at various freight rates.

Major Symons' report contains the most valuable collection of data referring to these matters, which has come to the author's knowl-

edge. An estimate of the cost of a ship-canal 28 ft. deep, made by eminent engineers, will shortly be made public. The 14-ft. canal from Montreal to the West, which will be opened next year, will probably soon supply valuable data in regard to the cost of transportation in large barges, in canals, and on the lakes.

There are two kinds of costs incurred in moving freight, cost of transport and cost of transfer. The best possible adaptation of the carrier to the route on which it travels will make the cost of transport the smallest. Canals of moderate depths will furnish very cheap transport if the carriers are especially adapted to them. This best adaptation of the carrier to the route, for the traffic between the lakes and Europe, is, however, only obtainable by transfers in New York and Buffalo. These produce large costs of transfer, and slowness of transportation, the latter a disadvantage difficult to be expressed in figures, unless the higher freight rates and larger amounts of business, which railroads are able to obtain, are taken as a measure of it. These costs of transfers can, on the route here considered, be partly avoided by using barges that are able to run safely and economically on the lakes and sea coasts. These barges, however, are not as economical on canals as mere canal barges, because the latter can be built much lighter. These lake barges need also a much deeper and more expensive canal.

All transfer costs of through freight and consequent delays are avoided by a canal accommodating ocean steamers.

Costs of transfer and costs of transport are two opposing factors, of which the first can only be avoided by at least slightly increasing the latter. It is very important to carefully determine what is properly chargeable to each, since an error in this respect must often lead to an erroneous choice between the three methods of transportation above mentioned. It is also important not to neglect the economic value of speed of transport which is largely the cause of the higher rates and larger amount of business obtained by railroads. Since the relative costs of transport and of transfer are so decisive, in the proper choice of method of transportation, Table No. 1 is given and shows the results of a calculation of these amounts, based on Major Symons' Table No. 32, with the assumption that one-third of the expenses of a steamer between Chicago and Buffalo, and of the barges between Buffalo and New York, and one-quarter of those of a steamer

between New York and Liverpool, are incurred while in port. Several columns have been added, and corrections made in regard to the cost of transport in lake vessels between Buffalo and New York, and several arithmetical errors, in Major Symons' table, have been corrected.

The canal of 12 ft. depth, recommended by Major Symons, would probably decrease the total cost between Chicago and New York by 2.12 cents per bushel, or 71 cents per ton, partly by forcing a reduction in transfer charges in Buffalo and partly by reducing the cost of transport in the Erie canal. It would probably bring about a reduction of transfer charges in New York for all freight going through it, estimated at 0.5 cent per bushel. It might do even better if it should prove practicable to build barges of 10-ft. draft, that could run economically on the lakes, canals and sea coasts. This saving would abundantly justify the expense of a canal 12 ft. deep if it were impossible to build one of a different depth that would give a better return on the capital invested. The saving obtainable by a canal on the Oswego route, of 18-ft. depth, and with a water-prism of 2 400 sq. ft., may be thus analyzed: Such a canal could be navigated by barges, which have proved by experience their ability to compete successfully with the cheapest means of transport on the lakes and along the sea coast from Virginia to Maine. They would have to run through 94 miles of canal and 94 miles of canalized river, while the 1 500-ton barges on the canal suggested by Major Symons would have to contend with 270 miles of canal and 73 miles of canalized river. The former would, therefore, do at least as well as regards cost of transportation, and very much better in regard to time. They would also save the transfer in Buffalo. The cost from Chicago to New York for a bushel of wheat would, therefore, be 1.14 cents less than on the 12-ft. canal (see Table No. 1), or a saving of 38 cents a ton on all freight to and from New York. If it be assumed that the 12-ft. canal would force transfer charges in New York, which are now for through business, inclusive of trimming on ocean carriers 1.7 cents, to 1.2 cents, there would remain a cost of transfer in New York of 2 cents, which would be saved on the 18-ft. canal for all freight going to near sea coast points.

Such a canal, having a smaller amount of contracted channel and avoiding transfers, would also give a considerable advantage in time, especially if the locks at Niagara Falls and at Cohoes could be

bunched into two of Mr. Dutton's pneumatic locks in the former, and one in the latter place. The difficulty of obtaining enough water on the summit level could also be solved by using these locks (which need only a small fraction of the water consumed by ordinary locks) in the two locks at the ends of this level. Such a canal, avoiding transfer in New York, would give the whole sea coast from Virginia to Maine the benefit of extremely cheap transport with the West, and would probably secure as much freight from, and to these sea coasts, as from, and to New York.

The saving on the 18-ft. canal, as against the present Erie canal, would be (see Table No. 1):

	Per ton.	Cents per bushel.
On freight to and from New York.....	\$1.09	3.26
“ “ Europe	1.25	3.76
“ “ near sea coast.....	1.92	5.76

The average is \$1.42 if equal amounts of freight be assumed for the three destinations.

On a business of 12 000 000 tons, which might reasonably be expected soon after the opening of a 12-ft. canal, the saving would be \$9 520 000, if it be assumed that one-half of it will go beyond New York. An 18-ft. canal could be navigated by the barges at present existing on the lakes and sea coasts. It would give speedier transport and could give cheaper rates, and would therefore have, from the beginning, a larger business than a 12-ft. canal. If it be assumed that it would obtain a business of 15 000 000 tons soon after the opening, it would give a saving of $\$1.42 \times 15\,000\,000 = \$21\,300\,000$ per year in cost of transport and transfer. It has been assumed, so far, that barges would not cross the ocean. Attempts have been made to build whaleback barges for ocean traffic, but if the author is not misinformed, they have failed on account of structural weakness. There seems to the author to be no doubt that ocean-going barges can be designed that could do business on the lakes, and on an 18-ft. canal, with fair economy; and, with anything near the present transfer charges, they would, probably, have an advantage over other carriers in through business between the West and Europe. There would be no difficulty in designing a proper attachment for the hauling cable to the barge or vessel to prevent its breaking on account of the inharmonious motion of vessel and barge produced by storms. Should a canal of 18 or 20

ft. depth be built between Buffalo and New York, the greatest possible inducement would be given to experiments in this direction, and there seems to be little doubt that they would be successful. In this case there would be much less inducement to build a ship-canal for ocean steamers than at present exists.

A canal of 18 ft. depth, with 2 400 sq. ft. of water-prism, on the Oswego route would probably cost about \$100 000 000. A canal of 24 ft. depth, with about 4 200 sq. ft. of water-prism on the same route is estimated by Major Symons to cost \$200 000 000.

The result of this argument is altogether in favor of large motorless barges as carriers on routes containing long stretches of canals, and promising a large business, because these make possible the avoidance of expensive transfers with only a slight increase in cost of canal transport.

The reason why motorless barges, fit for sea coast and lake traffic, are almost equally well fitted for traffic in a canal of sufficient depth, lies in the fact that they carry no motive power. The motive power for a vessel at canal speed of 4 miles an hour, in comparison with that required for economical speed on the lakes, say 13 miles an hour, is about one thirty-fourth of the latter. A carrier containing its own motive power, sufficient for a speed of 13 miles per hour, is very expensive per ton of carrying capacity; it makes up for this disadvantage, however, by its speed, and can thereafter do business on the lakes as cheaply as large barges at much slower speed on canals. Let this carrier come in the canals, where it is obliged to reduce its speed, and it suffers from the combined disadvantage of being very expensive, in comparison with its capacity; of needing a large crew; and its motive power, working at only a small fraction of its capacity, is extremely wasteful in coal, oil and supplies, as well as in attendance on engines and boilers. This is the main reason of the unfitness of either lake or ocean steamers for canal traffic. The motorless barges can be hauled, on the lakes or sea coasts, by powerful tugs at the speed of lake vessels, and on the canals, either by steam canal-barges, or by small tugs. The difference in design of lake and canal-barges is small in comparison with that between a vessel able to run 13 miles an hour, and a motorless barge, or a barge fit to run 4 miles an hour and haul a few consorts. Large motorless lake or ocean-going barges, therefore, fulfill most nearly the conditions for cheapest and speediest transport,

which are, absence of transfers and best adaptation of carrier to route.

It was above estimated that a ship-canal of 28 ft. depth would give a saving of 4.61 cents a bushel in the transportation of wheat from Chicago to Liverpool, in comparison with the cost on the present Erie Canal. This gives a cost of 7.5 cents, or 0.85 cent less than on the 18-ft. canal, with transfer in New York (see Table No. 1). This is 28 cents a ton, and at present would certainly not justify the enormous expense required.

For the business between the East and the West, such a canal would undoubtedly offer some advantages in allowing greater speed and larger barges or vessels, but with the present experience this advantage cannot well be expressed in figures.

The Suez Canal is now being deepened to 10 meters, and it is the expectation of many that this will make possible a speed of 7 miles an hour on the same. If these expectations are realized, it would be possible to calculate upon a greater speed for lake vessels and barges than has heretofore been assumed on a canal between Buffalo and New York. This would give a saving on the business between the Lakes and the coast which might justify at some future time the construction of such a canal.

All these calculations and inferences are evidently not more reliable than the data on which they are based, and this paper was not written with the purpose of settling the question in a decisive way, but with the intent of showing that it has not been settled, and giving a method of doing so.

The author hopes it has brought forward prominently the fact that, since a canal is built to diminish the cost of transportation, the question can only be settled by carefully analyzing this cost, separating it quantitatively into the different elements, finding how these elements are affected by different kinds of canals and carriers, and then choosing that combination which will make the sum of all the elements of cost a minimum. If this paper induces those who have pertinent information, in regard to the doubtful points that have to be accurately determined before the question can be decisively answered, to come forward and give it to the public, it will have answered one of its purposes.

TABLE No. 1.—ESTIMATED COST OF TRANSPORTATION, CHICAGO TO NEW YORK AND LIVERPOOL, BASED ON MAJOR SYMONS' ESTIMATE, IN CENTS PER BUSHEL OF WHEAT.

	Cost of carrier in Chicago.		Cost, Chicago to Buffalo.		Cost in Buffalo.		UP, 20 CENTS PER TON, TRANSFER DOWN, PER BUSHEL.		Cost, Buffalo to New York.		Cost of carrier from West, in New York.		Sum of columns 2, 3, 4, 6 and 7.		Sum of columns 2, 3, 5, 6 and 7.		Cost of transfer to ocean steamer in New York.		Cost, New York to Liverpool.		Cost of carrier in Liverpool.		Cost of transport, Chicago to Liverpool. Sum of 8, 6 and 11.		Cost of transfers. Sum of columns 2, 4, 10 and 12.		Cost of transfers. Sum of columns 2, 3, 5, 10 and 13.		Cost, Chicago to Liverpool. Sum of columns 13 and 15.		Cost, Chicago to Liverpool. Sum of columns 16 and 18.			
	¢	¢	¢	¢	¢	¢	¢	¢	¢	¢	¢	¢	¢	¢	¢	¢	¢	¢	¢	¢	¢	¢	¢	¢	¢	¢	¢	¢	¢	¢	¢	¢		
																																	Cts.	Cts.
By ship-canal, 24 ft. deep	0.23	0.91	0.23	0.91	0	1.55	0.23	0.91	0.62	0.16	0.62	0.16	3.47	3.06	2.01	3.03	0.65	5.46	4.44	4.03	9.90	9.49	0.23	0.91	0.23	0.91	0	1.76	0.23	0.91	0	1.76	0.23	0.91
By Erie Canal in present condition	0.23	0.91	0.23	0.91	0	1.55	0.23	0.91	0.62	0.16	0.62	0.16	1.92	2.01	3.03	0.65	5.46	4.44	4.03	9.90	9.49	0.23	0.91	0.23	0.91	0	1.76	0.23	0.91	0	1.76	0.23	0.91	
By Erie Canal as it is, being improved	0.23	0.91	0.23	0.91	0	1.55	0.23	0.91	0.62	0.16	0.62	0.16	1.92	2.01	3.03	0.65	5.46	4.44	4.03	9.90	9.49	0.23	0.91	0.23	0.91	0	1.76	0.23	0.91	0	1.76	0.23	0.91	
500-ton barge-canal, 12 ft. deep, with semi-independent motive power	0.23	0.91	0.23	0.91	0	1.55	0.23	0.91	0.62	0.16	0.62	0.16	1.92	2.01	3.03	0.65	5.46	4.44	4.03	9.90	9.49	0.23	0.91	0.23	0.91	0	1.76	0.23	0.91	0	1.76	0.23	0.91	
Barge-canal 18 ft. deep	0.23	0.91	0.23	0.91	0	1.55	0.23	0.91	0.62	0.16	0.62	0.16	1.92	2.01	3.03	0.65	5.46	4.44	4.03	9.90	9.49	0.23	0.91	0.23	0.91	0	1.76	0.23	0.91	0	1.76	0.23	0.91	

Column 8 gives cost from Chicago to New York, with transfer charges in Buffalo as they are at present.
 Column 9 " " " " reduced to 0.76 cent per bushel.
 Column 10 " " " " Liverpool, with transfer charges in Buffalo as they are at present.
 Column 11 " " " " reduced to 0.76 cent per bushel.
 It was assumed that the building of a 12, 18 or 24-ft. canal would produce a reduction in transfer charges in New York of 0.50 cent per bushel.

DISCUSSION.

GEORGE S. MORISON, Past-President, Am. Soc. C. E.—There are some features in Major Symons' report and in the author's criticism which seem to group themselves under general heads, to which it may perhaps be worth while to briefly refer.

The general question is, How shall our grain products be brought to the sea? That is the principal condition which has brought up this general subject. The grain-producing country has been moving further west and the manufacturing country has been following it, until now, in the older grain-producing country, all the grain produced is consumed by the manufacturing population, so that at present the greater part of the exported grain is raised some distance west of Lake Michigan. It is raised in a country much of which is as near the Gulf ports as it is to the lake ports, and from all of which it has to be transported by rail. Therefore the condition to be faced is that in which the transportation from the original producing area will cost about the same if taken to the Gulf as if taken to a lake port. With the present conditions in the Gulf ports, and the deeper water which has been obtained in the last few years, freight rates from Gulf ports are very much lower than they were formerly. In order to continue to take our export grain through the eastern Atlantic ports, and especially through New York, the rates from lake ports to European ports must be made about the same as from Gulf ports to European ports. Now this is bringing inland water and rail transportation between the lake ports and the Atlantic ports down to conditions of greater closeness than has ever been done before, and it becomes necessary, if business is to continue to come to New York, to eliminate every possible extra charge.

The great advantage which New York has over Gulf ports and over nearly all other Atlantic ports is that it is a great importing port, the other ports being simply exporting ports. New York furnishes cargoes for the ships that come there, and it would perhaps be more correct to say that it is a market for cargoes brought by ships from European ports, which can therefore afford to take their export cargoes for a less rate than cargoes can be taken from other ports. This is, primarily, the great advantage which New York has over every other port.

However, New York has its disadvantages. Ships enter, primarily, to deliver imported goods, almost all of which are manufactured, and these goods must be landed at places from which they can be distributed among the warehouses of the merchants who handle them, thus making the receipt of freight the first object in the harbor accommodations. In the other ports, which are all based upon export trade, a ship goes alongside of an elevator, her business not being to deliver a cargo of manufactured articles, but to take a cargo of grain

Mr. Morison, and get out. The result is that all those vessels which are practically carrying a cargo one way are able to load that out-bound cargo for a considerably less price than it takes in New York, where it has to be lightered and transferred.

Another factor is that grain must be transported to New York over a great distance. Practically the whole lake-borne grain trade is now received either at the head of Lake Michigan or the head of Lake Superior. The grain is transported on the lakes in large cargo-carrying steamers which are generally loaded to 14 or 16 ft., and which it is expected after a few years can be loaded to 20 ft. The lake harbors are at present of such a character that it would seem out of the question to increase their capacity to over 20 ft.; in fact—20 ft. seems to be a limit which is not likely to be passed. These lake steamers, bringing their cargoes to the transshipment point, which is generally Buffalo, are extremely cheap freight carriers. From Buffalo grain is carried by rail or by canal to New York and there again transferred to steamers. This method of transportation necessarily means three different classes of conveyance—the lake boat, the canal-boat and the ocean steamer. The elements of cost in handling this business may be stated to be three—the cost of actually doing the work, the interest on the investment, and the cost of transferring. The ocean steamer is the most expensive, the lake steamer is the medium, and the canal-boat is the cheapest craft, according to their respective carrying capacities. So far, therefore, as interest on investment is concerned, the less the ocean steamer is used and the more the canal-boat is used, the less this cost will be.

As to the cost of operation, per ton of carrying capacity, it probably does not differ very much in the lake boat and the ocean steamer, although the former would be the cheaper. The cost of operating the canal-boat would necessarily be more than either of the others, though not very much more. However, the mere cost of transportation is very much less than is commonly supposed; very little doubt existing that wheat could be taken from Buffalo to New York by railroad, being received in fully loaded trains and delivered in the same way, for very little more than 1 cent a bushel, for the simple cost of moving the train.

The other two items, the cost of the transfers, seem at present to be very much in excess of their proper relative values. If the cost of taking a bushel of wheat from Chicago to Liverpool be divided into five parts, the costs of lake carriage, of transfer at Buffalo, of canal-carriage, of transfer at New York and of Atlantic carriage, and if when that division is made the cost of each of the two transfers is fully equal or perhaps more than the cost of either the lake or the canal carriage, it seems as if there was something wrong. It has often happened that the cost of transfers was not due to what they ought to cost, but to what people wanted them to cost, like the system of tak-

ing toll on an old-fashioned turnpike—the owners of the turnpike had Mr. Morison. the right to take it, and, of course, they did. It cannot be expected that the people who handle the elevator systems and the various transfer methods at Buffalo will do it for three-quarters of a cent if the business is able to pay a cent and a quarter. The same thing is true in New York and of any business. But if this transfer could be broken up at Buffalo, not as a physical fact, but as a matter of business, that condition might be entirely changed. At present the principal inducement to construct a ship canal, which will bring lake carriers from the lake ports to New York, seems to be to avoid the transfer at Buffalo. The chief reason for constructing a colossal canal which will enable steamers of the class that now run from Liverpool to New York to continue their voyage to Chicago is to avoid the transfers at Buffalo and at New York.

One difficulty which at present prevails in shipping by lake and canal is that there is no single corporation or authority whose paper is of undoubted value, to give through bills of lading. At present railroads work in connection with lake steamship lines which they own. The reason why so large a portion of the steamship business on the lakes comes by rail from Buffalo is that the railroads own the boats and conduct the whole as a single line, and a responsible corporation gives through bills of lading which are accepted as proper security for advances. If the same unity of interest existed in water lines of transportation, the same class of an organization, it would practically obviate the whole difficulty of transfer. Suppose a single corporation operated a line of canal-boats either by ownership or charter between Buffalo and New York, and operated a line of freight carriers between Chicago and Buffalo, and gave through bills of lading from Chicago or Duluth to New York, is it not probable that the same corporation would find some method by which the cost of transfer at Buffalo was reduced from a cent and three-tenths, or the present rate, to something like a quarter of a cent? It is not so much that the difficulties of transfers cannot be eliminated as that the existing methods and interests do not desire to eliminate them.

Perhaps this is more of a business than an engineering question, but engineering certainly extends to these matters, and if the question came up on a purely engineering basis, how much it ought to cost to carry this business through, there is little doubt that methods would soon be found by engineers to reduce these transfer charges to so small an amount that they would be hardly more than nominal (instead of forming one-half of the rate from New York to Chicago). This seems to be the real gist of the subject. What is wanted is water transportation with as small an expenditure of capital as is necessary to make the transportation itself cheap, and then such business organization as will eliminate the cost of transfers.

Mr. Morison. The cost in cents of transporting a bushel of grain by water from Chicago to New York, including the transfer to ocean vessels, is given by Thomas W. Symons, M. Am. Soc. C. E., for four different methods of transportation,* which may be analyzed as follows:

Method.	Lake freight.	Buffalo transfer.	Canal freight.	New York transfer.	Total.
Ship-canal, 7 000 tons load.....	1.37 (p. 88)	.....	2.28 (p. 81)	1.27 (p. 88)	4.92
Present Erie Canal, 6-boat fleets.....	1.37	1.30 (p. 82)	2.41 (p. 88)	1.27	6.35
Improved Erie Canal, 6-boat fleets.....	1.37	1.30	1.41 (p. 85)	1.27	5.35
Barge-canal, 4-boat fleets.....	1.37	1.30	0.91 (p. 86)	1.27	4.85

In each of the first three cases the more economical method cited by Major Symons has been selected, in the fourth case the less economical method is taken. The table, therefore, does not favor the barge-canal. This table further makes no provision for any profit to the canal carrier beyond interest on investment and allowance for depreciation. If the transportation charges and the transfer charges are separated the following results obtain:

	Transportation.	Transfers.	Total.
Ship-canal, 7 000-ton loads.....	3.65	1.27	4.92
Present Erie Canal, 6-boat fleets.....	3.78	2.57	6.35
Improved Erie Canal, 6-boat fleets.....	2.78	2.57	5.35
Barge-canal, 4-boat fleets.....	2.28	2.57	4.85

It will be noted that by the barge-canal the transfer charges exceed the cost of transportation. Furthermore, it is shown that the cost of transportation is greatest on the ship-canal and least on the barge-canal. The New York port charges are the same for all methods, but everything saved on the transfer charges between the lake vessels and the canal barges accrues to the benefit of the canal route and strengthens the argument in favor of the barge-canal. This shows what can be done. It would seem quite possible that grain can be transported from Chicago to New York by lake and the barge-canal, including an economical transfer, for 2.5 cents per bushel, or 83 cents a ton, covering 1 400 miles of water transportation at a rate of less than six-tenths of a mill per ton per mile. To meet this rate the railroads would have to transport on their more direct routes for about eight-tenths of a mill per ton per mile. The cost of transportation from Buffalo only, would be about 30 cents a ton, or three quarters of a mill per mile, if carried by railroad. If this can be accomplished, the functions of the canal will no longer be those of a regulator of rates.

* Pp. 82-88 of his Report which correspond to pp. 3209-3215 of the Annual Report of the Chief of Engineers for 1897.

EDWARD P. NORTH, Vice-President Am. Soc. C. E.—The thanks of Mr. North. the Society are due the author for the very careful and able analysis of the data in hand which has been presented to-night; particularly as his analysis agrees in its conclusions with observed facts, a result not always reached by analogical discussions.

Exceptions, however, might be taken to the statement: "The Northwestern States are vitally interested in reducing freight rates to Europe, even more than in reducing rates to home markets, since the home price of produce, which is exported in considerable quantities, is equal to the price in the principal foreign markets, less the cost of reaching them." Not that the statement is incorrect, but that in nearly all the writings on this subject our export of crude agricultural produce is given too much weight. While such exports form a valuable asset, they are also a badge and sign of financial, and generally of industrial, inferiority; the country living by such exports being regarded as "a hewer of wood and drawer of water" for the countries consuming their products. There is also a colonial and inferior posture on the part of the vending toward the purchasing community.

Over one hundred years ago Adam Smith pointed out that when goods were raised in Great Britain, then not entirely free from the exportation of raw materials, and consumed in Portugal, there were two capitals employed and two employments given, one British and one Portuguese; but if the goods were consumed in Great Britain, both of the capitals and employments were British. For many years both the capitals and employments connected with consuming or advancing our raw products were foreign. In 1860 the value of our exports of manufactured goods was but little over \$40 000 000. Ten years ago, the fiscal year 1888, the value was, in round numbers, \$130 000 000, but for the last calendar year it was very near \$290 000 000. These figures will probably receive as great an increase during the next ten years as in the preceding decade.

It seems certain that we will continuously increase the percentage of manufactured goods exported, and that our trade, instead of going in large bulk, with small profit per unit, to compete at foreign manufacturing centers with the raw products of countries with a low civilization, will more and more be directed to those countries which in consequence of their poverty and lack of manufacturing organization are forced to buy at a high price per unit. Any such result of our manufacturing activity would at first call for mixed cargoes and vessels of smaller capacity than those now engaged in the transatlantic trade. And with a competent channel between the sea and the manufacturing industries on the lakes, we will doubtless be able to develop a class of vessels available for navigation on both salt and fresh water.

One of the written discussions on this subject is based on the general laws of political economy which are said to be natural laws, as inexorable

Mr. North. in their operation as the law of gravity. As the conclusions reached are of great moment to the discussion in hand, and as there may not be general acquiescence in the speaker's view that all the inexorable laws of political economy are founded on the method of assuming principles and ignoring facts, reference is made to the very able report of Major Symons, mentioned in the paper now under discussion, which sets forth that only 5.9% of the cereals grown in the United States are exported, that only 58% of the grain brought to the six largest exporting ports on the Atlantic coast is sent abroad, and only one-third of the cattle which are brought to the four cattle exporting ports, the remainder being retained for home consumption.

The area on which grain can be grown for market depends largely on the cost of transportation, but the transportation of grain has been, in the past, a greater factor than all others in the development of our railroads, and an important factor in the phenomenal decrease in our freight rates, a reduction that has frequently been alluded to before this Society. With each decrease in freight rates the area of profitable grain raising has increased, with an increase in railroad mileage. Concurrently the consumption of manufactured articles by our wheat growers has built up and supported our manufacturers, giving farmers a near-by market, reducing their freight bills, both by lessened distance and a lessened rate per mile. This reduction applies to the 94.1% of grain which we do not export, as well as to that exported. Any reduction in the cost of transportation due to an enlargement of the Erie Canal for export purposes would influence the entire crop and be divided between producer and consumer, for the decreased cost would force improved methods on railroads competing with canal traffic, and these improved methods, as heretofore, would be the common property of the whole country.

In any market the price of a commodity will depend on and be governed by the price of the dearest portion of that commodity finding open sale in that market. Hence if we can cut four or more cents off the cost of marketing our wheat, while our rivals cannot decrease the cost of marketing theirs, our producers, and not foreign consumers, will have the sole advantage.

If our producer was to receive no benefit from an enlargement of our waterways and the consequent reduction in freight rates, except in the cheapening of domestic and foreign commodities which he receives in exchange for his grain, the gain would be too small to warrant consideration.

As mentioned above, nearly all consideration of the demands for a lower freight rate between the lakes and seaboard are based on the transportation of grain, which, on account of its value, and the ease with which it can be transferred, is the principal freight of the Erie Canal. But in spite of this ease of transfer it forms a considerable

portion of the cost of freight between Chicago and the City of New Mr. North York. In Table No. 22 of Major Symons' valuable report, it will be seen that for the five years ending with 1896, the average freight charge per bushel of wheat by lake and canal, from Chicago to New York, has been 6.059 cents. Of this 1.368 cents were net rates from Chicago to Buffalo, and 3.181 cents between Buffalo and New York. If the distance from Chicago to Buffalo be taken as 1 000 miles, and from Buffalo to New York as 500 miles (150 miles of which are open river), it is seen that only the insufficient cross-section on less than 25% of the distance, and the transfer charges made necessary thereby, prevent this freight charge being reduced to 2.052 cents per bushel, and freight should go through from Chicago or Duluth to New York for less than \$1 per ton.

Any such reduction would probably repay the country each year for the necessary cost of a canal of large section. There would be the direct payment, in a higher price for all grain, and indirectly, the saving on freight carried through the canal; 18 982 755 tons of freight were carried through the Sault Ste. Marie in 1897. It is asserted that the average cost was two-thirds of a mill per ton-mile. Assuming an average length of voyage of 800 miles, the saving at this rate over an equal haul by rail at $8\frac{1}{2}$ mills would be nearly \$119 000 000, or 40% on all moneys appropriated for harbor and river improvements up to this date. Applying the above rates to the assumed 24 000 000 tons carried 1 200 miles, which is less than the average voyage through the canal, the difference between the two would be \$225 600 000, nearly equal to the most obstructive estimate made of the cost of this improvement.

Claims are made that the well-known reductions in freight rates are entirely due to improvements in our waterways; they are undoubtedly concurrent with such improvements, though, if, at the same time, railroad rates had not been reduced, the volume of freight offered for transport would not have allowed the reductions on either rail or water transportation. A generally overlooked value, following the reductions of freight rates, is the encouragement they afford for the production and transportation of low-cost commodities. One of the most marked instances of this kind is cited by E. S. Wheeler, M. Am. Soc. C. E., for some time the Assistant Engineer in charge of the United States Locks at the Sault Ste. Marie. He says that one-half the freight passing that point is not valued at the cost of railroad freight to the docks at which it is landed. If the Lake Superior iron ore had to pay European freight rates the manufacture of any large amount of iron and steel in this country would be an economic impossibility, and our present large employment of labor and capital in that industry would be lost to this country, and the reduction in price, which has resulted from our large output, would be lost to the world.

All of these considerations point to the economic advantages presented by a channel of communication so ample and capacious that not

Mr. North. only at present, but in the future, the traffic between the West and the seaboard shall meet with the least possible resistance, either in time or labor; so that the inevitable cost of transportation may be reduced to a minimum, and the amount transported be so increased that an alternative route is justified. This channel should end in New York, because as shown in the discussion of the paper by T. C. Clarke, Past-President Am. Soc. C. E.,* the market presented on the shores of the harbor of New York is worth more to the western farmer than all the rest of the world outside the United States; also, because New York, now the largest manufacturing center in the world, should increase the area she serves, and a reduction of transportation charges for her products presents the only certain means of securing this end. Or, in other words, the two localities of largest production and consumption should be united by the cheapest possible transportation.

Many of the people inhabiting the State of New York oppose such a channel. This opposition found official utterance in a report by a State Superintendent of Public Works, as follows:

"It is clearly evident that the duty of the Legislature would be to provide the means for the construction of the largest possible canal, intended for the navigation of boats of such construction as will be able to navigate the inland waters of this State, discharging and receiving their cargoes at Buffalo and New York, or other intermediate points."

This view of the duty of the Legislature probably had its origin in the fact that during the forty-five years preceding 1882, when tolls on the canal were abolished, the State exacted \$120 331 937 in tolls on merchandise passing through its canals. Notwithstanding the fact that a large part of this exaction was taken from the incomes of those engaged in developing the West, and curtailed the development of the manufactures and commerce of New York, all this vast sum has been regarded as clear gain to the State, and \$9 000 000 were lately voted for an enlargement of the canals which will not, when completed, appreciably enlarge the area served by any industry in the State, but as then estimated by the Governor would allow, abstracting a further sum from passing traffic through elevator charges and an unnecessary freight rate.

Major Symons, in the report already referred to, thinks he has found in a depth of 12 ft. and in barges of 1 500 tons capacity an approximate solution of the problem, adding: "A ship canal between the Great Lakes and the ocean would have no military value." It would, however, apparently have a considerable naval value just at present, and at all times by making the skill and capital now employed in shipbuilding on the lakes available for that purpose it would facilitate any effort to control our own appliances for conducting our foreign commerce. As there is no place at present where ships can be built at so small a cost, either in money or labor, as on

* *Transactions*, Vol. xxxv.

the lakes, it is not improbable that the value of shipping constructed Mr. North there would amount to \$50 000 000 in some years if convenient access to the sea could be had.

It is evidently expected that the 1 500-ton barge would obviate elevator charges at Buffalo. This may be doubted. When the late Colonel O. M. Poe, M. Am. Soc. C. E., started to increase the depth of lake channels to 20 ft. (for which his reward was a splendid monument in the affection of the people and in the increased wealth of the country), he expected to cut lake freight rates in two by increasing the size of the vessels used to 5 000, and even 7 000, tons. The size of new vessels has closely followed the lines made practicable by the increased depth of channels. An increase in the number of 1 500-ton vessels would not have decreased freight rates from 2.3 mills to two-thirds of a mill, and the large vessel will, as a general principle, come as far east as the depth of channel will allow.

At the Cleveland Deep Waterways' Convention, September, 1895, President Livingstone, of the Lake Carriers' Association, said that, on the best attainable estimate, from 35 000 000 to 40 000 000 net tons of freight were passing through the Detroit River, "of which two-thirds would be primary products going somewhere for manufacture." The high cost of transfer into even 1 500-ton barges will effectually prevent any portion of the 24 000 000 tons of primary products going somewhere for manufacture, above mentioned, passing into the interior of the State or to the City of New York for manufacture. And any estimate of the traffic on a canal of large section based on the traffic now in sight will be as misleading as that based on the traffic between Lake Superior and the lower lakes before the first locks at the "Soo" were built.

The effect of transfer on the production and transportation of commodities of low value is shown by the report of a board of army engineers appointed to survey the Ohio State canals, who say: "The cost of once unloading and reloading a cargo of coal would carry it, at the rates of 1894, 291 miles on the Erie Canal, 946 miles on the lakes, or 1 060 miles on the Ohio River," or, in other words, nearly the whole length of the lakes, or 80% of the length of the canal, without transfer. Yet it is proposed to handicap the industries of the State by the expenditure of \$50 000 000 for the construction of a canal for the accommodation of boats that will continue to discharge and receive their cargoes at New York and Buffalo. Between 1887 and 1897 the lake freights were reduced from 2.3 mills to 0.67 mill per ton mile, or 70%, through the deepening of the channels, but such advantage is to be denied to the people of the State and of those States to the west of us that 4 or 5 cents per bushel may be taken from the price received by our largest customers for their grain.

A belief has been expressed that some advantage may accrue from having the main or arterial canal in a system of navigation no larger

Mr. North. than possible canals, which may act as feeders. This was not the plan adopted by the German engineers when improving the Main between Frankfort and the Rhine. They increased the depth from $2\frac{1}{2}$ to $7\frac{1}{2}$ ft., at a time when the governing depth on the Rhine was 6 ft. The result has been that the freightage on the Main, which for 1884-85 averaged 150 660 tons, increased to an average of 879 070 for 1895-96; for the same periods the railroad freights at Frankfort increased from 880 522 to 1 688 260 tons. In the meantime, the traffic on the Rhine has about doubled, and that river is being deepened. As a matter of fact, though cars of different gauges cannot be successfully run on the same line of rails, boats of different capacities can be operated on the same water course, with no greater disadvantage than the higher cost per unit in the smaller boat.

When it comes to the economic advantages of speed, however, as referred to by the author, the small boat has a widely recognized advantage. This is shown in the following table, taken from a paper by E. H. Stieltjes, presented at the Sixth International Inland Navigation Congress, held at the Hague, 1894, which gives the permissible speeds on various canals in Holland for boats of different drafts:

TABLE FROM E. H. STIELTJES PAPER.

Areas in square feet.	Depths in feet.	MAXIMUM SPEED IN MILES PER HOUR FOR SINGLE BOATS.					
		Draft of water in feet.					
		Up to 3.28	Up to 4.92	Up to 6.56	Up to 8.2	Up to 9.84	More than 9.84
.....	6.23	7.46	5.6 to 4.86	7.46	.....	.....	.....
.....	7.38	7.46	7.46	.....	.....	.....	.....
.....	10.33	5.6	5.6 to 4.66	3.62	3.62	3.62	.....
1 119	13.12	7.46	7.46 to 6.52	6.52	5.6	4.66	.....
1 417	18.	9.3	9.3	9.3	7.46 to 5.6	5.6 to 4.66	4.66
1 493	19.36	9.3	9.3	7.46	5.6	5.6	4.66
2 092	19.85	9.3	9.3	7.46	6.3	6.3 to 5.4	5.4
1 748	21.3	9.3	9.3	9.3	5.6	5.6 to 4.66	4.66
.....	24.4	9.3	9.3	9.3	5.6	5.6 to 4.66	4.66
3 640	25.26	9.3	9.3	7.46	5.6	5.6	5.6

NOTE.—Where the area of cross-section is not given, the canal cited varies in width.

This table shows that it is only on canals with a depth of 18 ft. or more that a speed of 9.3 miles is allowed to boats having approximately the draft of the Erie Canal boats, and with a canal having the cross-section proposed by Major Symons for his ship canal, viz., 4 176 sq. ft., and the same regulations as in Holland, there would be nothing but a lack of power to prevent a canal boat making the trip from Buffalo to New York in two days and a half. While this would not be done as a business operation by a freight boat, all freight would be moved on such a canal at a much higher rate of speed than

at present, at less cost and at a greater profit. The canal would also be Mr. North. used for passenger traffic if of sufficient cross-section. Mr. Stieltjes says there are about one hundred and thirty companies or contractors who have established regular passenger steamboat service on the Holland canals and the rivers and bays they connect.

It seems, to the speaker, unfortunate that the author of the paper under discussion did not more thoroughly investigate the advantages and disadvantages of the Oneida Lake route.

The chief physical features of the two routes as given in Major Symons' report are:

	Miles.	Differences in elevation.	No. of locks.
Oneida route.....	483	916 ft.	42
Erie Canal.....	496	555 "	26
Differences.....	13	361 "	16
Percentage of difference..	2.7	65	61.5

The distance *via* the Erie Canal will be modified by the necessary change of location. The number of locks given is, of course, tentative, but there probably will be no material change in elevations. It should also be noted that the Erie Canal route has only 226 miles of river and canalized rivers, while the Oneida Lake route has 31 miles of canalized and 132 miles of lake navigation which is replaced by a canal channel on the Erie Canal route. These two last-mentioned items, with a possible saving of 3% in distance include all the advantages presented by the Oneida Lake route.

On the other hand, the route cannot be considered "wholly within the United States" without some stress on the usually accepted meaning of the word "wholly." For 112 miles, from Olcott to Oswego it will be in waters to which the United Kingdom of Great Britain and Ireland have as much claim as the United States. And a route including Lake Ontario could be made tributary to Montreal, with less expense, either for construction or operation, than to New York. The Canadians understand this point fully.

Traffic by the Oneida Lake route has to overcome 65% more ascent and descent than by the Erie route, and while a canal by the last-mentioned route can be fed entirely from Lake Erie, adding a much-needed tribute to the waters of the Hudson, the Oneida route will either have to pump water for lockage or bring it from Lake Erie on substantially the route proposed by Elnathan Sweet, M. Am. Soc. C. E., in his paper urging a radical enlargement of the Erie Canal read June 10th, 1884.

Assuming that freight boats will pass over the 132 miles of lake navigation at the rate of 13 miles per hour, the time expended will be ten hours. Assuming, also, that an equal distance in the canal, to which should be added the 13 miles by which the Erie route is the

Mr. North. longer, is traversed at the rate of 5 miles per hour, the rate on the Suez Canal, twenty-nine hours would be expended, or nineteen hours more than by the Oneida route, but the sixteen additional lockages would occupy from thirty to forty-five minutes each, so that the entire saving of time would be from seven to eleven hours per trip. This is about 13% of the time to be spent in the canal, or 6% of that between Chicago and New York. But it may be doubted if this saving of time would compensate for unavoidable delays and dangers connected with the 361 ft. of extra lockage. Besides this, none of the canal boats now in use would be available on this route, but would have to be retained on the old State canals.

By adopting the Oneida route the traffic of the Great Lakes and the country to the west would tend to develop the industries of the St. Lawrence valley. The well-established manufacturing industries on the banks of the present canal, west of Rome, would be starved by cheaper transportation to the north of them, to which they would have no convenient access, and the possibility of building up great shipping points at the heads of the Cayuga and Seneca lakes, which would afford the West the cheapest possible anthracite coal route, will be postponed indefinitely.

The author says, "the question can only be settled by carefully analyzing this cost" of transportation, "separating it quantitatively into the different elements," etc., and full adhesion is given to the necessity for this analysis, but it is suggested that a survey developing the different routes with such detail as to allow engineers to make a responsible estimate of the cost of canals by different routes and of different prisms is more desirable at present than an analysis of the various elements making up the aggregate cost of transportation.

It is now nearly fourteen years since Mr. Sweet read his paper before this Society advocating a canal large enough to pass the largest vessel then navigating the lakes, and calling public attention to the fact that such a canal could be built without any grade adverse to the heaviest part of the traffic. During all these years not one cent of either State or National money has been expended for surveying the route he roughly indicated. However, one mixed commission, appointed and paid, as to the interests of the United States, by the Government, has reported as to alternative routes, both through Lake Ontario, and another commission, entirely domestic, is now making surveys, with no official right to examine or report on any portion of the Erie Canal situated in the State of New York west of Rome.

As the cost of freightage is reduced and speed is accelerated in channels of largest cross-section, the plan of taking the commerce of the country up and down a marine staircase presents a possible slight saving in time of transit, but its adoption would ignore the benefits of way traffic, and result in developing the industries of a foreign country

and turning back the prosperity of the western part of the State. Mr. North. There seems no stronger argument in favor of a canal through the State of New York, having a section too small to accommodate the largest boats trading on the lakes, than the old narrow-gauge argument, that the people could be induced to expend their money more readily for an insufficient than for an ample and commodious improvement.

EMERSON FOOTE, Esq.—The speaker may be thought very radical, Mr. Foote. but his position is based on many years of personal and practical experience in the transportation business on the Erie Canal. With others, he successfully introduced and operated, in a commercial way, the train-barge system of steam towage by submerged wire cables on the Erie Canal between Buffalo and Utica; using the present canal-boats without any expense for their special adaptation to that system, and at the same cost to boatmen, but with double the speed of animal power.

These relations to the Erie Canal and its traffic have caused this opinion: That while the improvements made by the expenditure of the \$9 000 000 already appropriated and the \$7 000 000 additional appropriation necessary to complete them, in accordance with the plans of the State, will greatly increase the capacity and facilities for moving the present and future tonnage, yet the Erie Canal, as constructed prior to these improvements, was an adequate means of transportation between the lakes and the seaboard, at a cost per ton-mile too low for profitable competition by trunk railways.

In order to ascertain the capacity of the Erie Canal, which is limited to the time required to lock a canal-boat, the State of New York made a 24-hour test at the Alexandria locks, near Schenectady, which resulted in establishing a capacity of 9 000 000 tons with single locks. With the present double locks the capacity would be 18 000 000 tons. The substitution of drop gates for the swinging gates now in use will reduce the time of lockage, determined by that test to be four minutes on the average, to two minutes, and increase the capacity of the canal to 36 000 000 tons.

The author mentions 12 000 000 tons as the business that might be expected soon after the opening of the proposed 12-ft. canal, which is only two-thirds of the present capacity, according to the State estimate; but it is very doubtful if such an enormous volume of freight would ever accumulate at Buffalo for east-bound canal transportation, or that 7 000-ton barges, much less 1 500-ton barges, could move that amount of freight in the usual 200 days of the canal season. To accomplish this a 7 000-ton barge must be loaded and dispatched every three hours each day. There are not the trunk railway facilities at Buffalo to ship east 2 000 freight cars, each loaded with 30 tons of freight, in twenty-four hours, or 12 000 000 tons during the season of canal navigation.

The greatest total tonnage ascending and descending on all the

Mr. Foote. State canals in one season was 6 673 370 tons in 1872. In 1896 the whole number of tons carried was 3 714 894.

Until the total tonnage ascending and descending in one season on the Erie Canal, Buffalo to Hudson River, amounts to 10 000 000 tons, the canal as now constructed will satisfy any demand of trade between the lakes and seaboard.

The present 7-ft. depth of the Erie Canal is ample to move, by the cable system, trains of ten loaded canal-boats, each of 240 tons capacity, at a speed which allows such a tow to leave Buffalo every two hours, amounting to 28 000 tons daily, or 6 000 000 tons during the canal season.

The query suggests itself as to the supply of water needed for full banks with a depth of 12 ft., as it is manifest that a uniform depth of even 9 ft. demands almost one-third larger supply than the present 7-ft. depth, with which depth the navigation of the canal is at times almost suspended for want of water.

The canal may be enlarged as contemplated by Major Symons, and the depth increased to 12 or 24 ft. with a 100-ft. prism, but its then enormous capacity could not be as acceptably utilized by steam barges, moving at the speed obtained in the Suez Canal, of only 7 miles per hour, as it could by the proven cable system of steam train-towage. A greater speed of 8 to 10 miles per hour may be obtained, and more tons moved in a canal season by the cable system, using canal-boats of reduced tonnage, than by the larger type of canal-boat now in use. Speed is the certain element in canal transportation which increases traffic, reduces the cost of transportation and brings back to the canal large quantities of freight now shipped by rail because of quicker transit.

In the speaker's opinion, the needs of increased trade on the canal are adequately to be supplied by equipping at a cost of \$2 000 000, instead of \$50 000 000 for a ship canal, the present Erie Canal with the steam train-towage system. It is cheaper than animal power, or the locomotive, and ensures a speed of 6 to 10 miles per hour, using the present canal-boats.

The cable system should be supplemented by having a few transportation companies conduct the whole business of the canal, issuing such a bill of lading as Mr. Morison mentions, and soliciting trade in the East and West as is now done by railways.

Above all, the Legislature of the State of New York should cease enacting laws which minimize the usefulness and value of the canal, such as the \$50 000 capital limitation of the transportation companies. The owner of one canal-boat using animal power has his unprogressive interests always safe-guarded, to the great injury of those interests which will make the Erie Canal as now constructed of great public use and benefit.

CORRESPONDENCE.

J. P. FRIZELL, M. Am. Soc. C. E.—Admitting the correctness of Mr. Frizell. the author's conclusion, that a 28-ft. system of navigation would affect a saving of 4.61 cents per bushel on grain from Chicago to Liverpool, and further admitting the doubtful proposition that the saving, coupled with collateral and incidental advantages, would pay interest on the outlay involved in such a system of waterways, a very important question as to the feasibility of such an outlay still remains. It is of an economic rather than an engineering character, but economic questions have to be considered in judging engineering propositions. The question is: Who gets this 4.61 cents? The western producer is enlisted in the project by vociferous assurances that he will get it, and the eastern consumer is promised with equal confidence that he will get it. In point of fact, who is benefited by this reduction in freights?

It must be assumed that this subject is in no way exempt from the operation of the general laws of political economy. The proposition is: To diminish, at public expense, the cost of American grain, as delivered on the Atlantic seaboard and in foreign countries. The economic effect of such a measure is precisely the same as if the diminution of price arose from the introduction of improved machines or improved processes of cultivation. It is well known to political economists that the effects of such improvement are of the following threefold character. At first it inures wholly to the benefit of the producer and raises his profits above the general level. Second, it stimulates production and attracts capital and labor. Third, by the competition of producers in the market, it diminishes prices and brings the producers' profits back to the normal rate, leaving the price lower *ceteris paribus*, by the exact equivalent of the improvement. There is no reason to suppose that the results will be exceptional in the case under consideration, the entire benefit of the reduction passing after a few years to the consumer in the form of lower prices, whether in this or foreign countries. All this comes about by the operation of natural laws as inexorable as the law of gravity. The expenditure, therefore, so far as it affects the price of grain, ultimately inures wholly to the advantage of consumers, and not at all to that of producers, except in the one contingency to be pointed out.

As regards domestic consumers, it may reasonably be alleged, that expenditures made for their benefit are not thrown away. As to the foreign consumers, it is not easy to see why this Government should spend some hundreds of millions to enable them to buy grain cheaper, unless there is reason to apprehend that the competition of other grain-producing countries will deprive us of their market. In such case the

Mr. Frizell. expenditure would be of advantage to American producers as tending to prevent their expulsion from foreign markets, though when we consider the vast territories in India, Russia, Siberia and South America capable of producing grain, it is manifest that an advantage of 4.61 cents per bushel can cut but a small figure from that point of view. Aside from this consideration, the expenditure can benefit the American producer in no way, except in the cheapening of the domestic and foreign commodities which he receives in exchange for his grain.

Mr. Symons. T. W. SYMONS, M. Am. Soc. C. E. —Though honored by the author's review and criticism of the writer's report on the subject of a deep water-way between the lakes and tide-water, the reception of which by the engineering and business world has been so gratifying, the writer cannot agree with him as to the greater advisability of building an 18-ft. canal by way of Lake Ontario instead of a 12-ft. canal by way of the Erie Canal route.

The writer has never claimed, felt or believed that his report embodied the ultimate wisdom in this canal question, but always expected that it would be subject to thorough discussion and revision. In the report advocating a barge-canal, it is stated:

"It is not to be understood that the size of barges and barge canal mentioned is to be considered as definitely fixed. It is simply taken as a type of about the size which would be the most economical and advantageous. There are business reasons which would indicate that a smaller unit than a 1 500-ton barge would be preferable, and others that a still greater enlargement would be desirable. A careful balancing of all interests would be required to fix upon the most advantageous size. The size fixed upon in this report is to be regarded as a first approximation thereto."

Time will not permit the writer to discuss the author's able article at length, and he must give his conclusions and impressions more fully than the reasons upon which they are founded. He is still convinced that the greatest good to the greatest number will be attained by constructing along the Erie Canal route a barge-canal of about the capacity and upon the lines which he has suggested and which was at an earlier day suggested for enlargement by State Engineers, Elnathan Sweet and Horatio Seymour, Jr. Such a work will give a fair return for the money invested, which a larger canal will not do.

The size of the proposed canal, with a depth of 12 ft. and a prism of a little over 1 200 sq. ft., is about as large as would be practicable on the Erie Canal route, for the boats would have to return up light many times, and the attainable headroom under bridges is limited, and the expense of culverts and other structures would increase enormously with greater depth. It is also believed that the barges specified are about as large as can be practically handled in pairs through the canal and locks.

The author has devoted himself too largely to theoretical possibilities, not giving proper consideration to conditions which exist now and which will exist in the future, and to which everything is tending. It is in a high degree pure theory to base estimates of cost of transportation on a loaded ship making a round trip from Buffalo to New York and back in $7\frac{1}{2}$ days and maintaining this rate throughout the season. To base estimates upon such a proposition would be about as erroneous as to base calculations regarding railroad transportation on the occasional trial trip of a lightning express.

The author has very greatly exaggerated the difficulties and expense of transfer at Buffalo and New York, both under existing conditions and under conditions which will exist in the future. He charges to the grain cargoes the entire cost of the ship's detention in port, which is far from proper. At the Port of New York, during 1896 78% of the grain exported was shipped as berth cargoes, and it is probable that few of the vessels carrying this grain were appreciably detained in loading it. It should also be remembered that if a ship-canal from Lake Erie to New York existed, lake vessels coming down from Chicago or Duluth with loads destined for New York, would ordinarily stop in Buffalo long enough to coal up for the trip to New York and back, as well as to lay in other supplies, make repairs, etc. The detention for this cause at Buffalo would be little less than the detention caused to the vessel by unloading a load of grain at the Buffalo elevators. For similar purposes it would stop on its return trip.

Probably the great bulk of foreign shipments from New York will in the future be almost entirely confined to berth shipments in the enormous freight-carriers like the *Pennsylvania*, *Kaiser Wilhelm II* and ships of like character, capable of carrying from 20 000 to 30 000 tons and drawing 30 ft. of water and over, and that the business of the lakes will be done in great lake steamers drawing 18 to 20 ft. and carrying from 6 000 to 10 000 tons, and that the problem is really limited to determining the best method of connecting these two characters of ships, that is, transferring the cargo of the big lake ship lying in a lower-lake port to ocean ships lying in New York Harbor, and *vice versa*.

The best and most economical method for accomplishing this connection would be by cheap barges suited to navigate a barge-canal built along the general line of the Erie Canal. These barges could be loaded directly from the lake ship at an expense which should not exceed $\frac{1}{2}$ cent per bushel, and be transferred directly from the barge to the ocean ship in New York at an expense which should not exceed an equal amount, $\frac{1}{2}$ cent per bushel, and with little delay to the ships at the lake or ocean port. The use of the permanent fixed elevators at either end would be avoided for the great bulk of the traffic, and

Mr. Symons. any figures which have been given as to the ultimate cost of transportation between Chicago and Liverpool would be greatly modified.

The author states that if a ship-canal existed, facilities for loading and unloading would be provided in New York, at least as good as those existing in Buffalo. This is probably true if the ship from the lakes were taken to a fixed permanent elevator to be unloaded, but in this case her cargo would require to be handled a second time, and the extra cost of storage and of the additional handling would more than make up for the advantages of quick dispatch gained.

He also states that if a ship canal existed

"The only additional time required for the round trip from Chicago to New York and back instead of to Buffalo and back, would be the time required for going and coming from Buffalo to New York. This time with an average speed in canal and canalized river of 4 miles and a speed of 13 miles in lake and river, would be 7 days 12 hours and not 22 days as Major Symons estimates."

Regarding this criticism as to the probable time of making a trip by ship canal from Buffalo to New York, the following table shows in detail the Oswego-Mohawk route and the estimated time of a loaded ship in passing the same:

Locality.	Character of waterway.	Miles in length.	Rate per hour.	Time, hours.	Locks.
Buffalo to Black Rock.....	Canal.	4	4	1	1
Black Rock to Tonawanda.....	River.	10	10	1	1
Niagara Ship Canal.....	Canal.	25	4	6	13
Lake Ontario.....	Lake.	112	10	11	
Oswego River.....	Canalized river.	21	4	5	5
Oneida River.....	Canal.	10	4	3	1
Oneida Lake.....	Lake.	20	10	2	4
Oneida Lake to Little Falls.....	Canal.	50	4	13	11
Mohawk River to Cohoes.....	Canalized river.	73	4	18	
Cohoes to Troy.....	Canal.	5	4	1	6
Troy to New York.....	River.	153	10	15	
		483	.....	76	42

Time sailing 76 hours.

Time passing through locks, 42 locks, $\frac{1}{2}$ hour each..... 21 "

97 "

Suitable allowance must be made for delays likely to occur, head winds, fogs, storms, passing other steamers *en route*, waiting for other steamers at locks, delays resulting from sailing during dark nights, passing highway and railroad bridges, accidents to vessels, locks, bridges, etc.

These delays may be safely assumed at 25% of the total estimated time of passage, making the necessary time from Buffalo to New York or *vice versa* 121 hours, or a little over 5 days for a single trip, or 10 to 11 days for a round trip. On the assumption of 10 trips per season, half of the time, or 11 to 12 days, would be spent in port. It is be-

lieved that this would not be found an excessive time for a ship to Mr. Symons. unload and load in New York harbor, unless it were willing to pay additional storage and transfer charges, which would probably more than make up for the delay which would be required to distribute its load and receive its upload with the least possible outlay of money.

No figures based upon single trips are reliable. The business must be extended over an entire season to arrive at anything like accurate conclusions, for it must be remembered that business does not always offer to ships and they must wait for it; that on the lakes as well as elsewhere ships are generally built in excess of the demand for tonnage; that the flow of grain and all products is intermittent, and that, with the best of arrangements and management, ships are detained in port for a multiplicity of reasons.

It was only after giving a full and careful consideration to all these items that the writer, in making his estimates, fixed upon 10 round trips per season between Buffalo and New York as a fair average.

The author states that in the determination of the most economical method of transportation between the Great Lakes and Europe there are three alternatives to be considered.

"First.—Lake steamers on the lakes, barges on the canals and river, and ocean steamers from New York. This method offers the cheapest transport on lakes, canals and ocean. It requires only a cheap canal of moderate water-prism between Buffalo and Albany. * * * * * The delays caused by transfers make this the slowest method. It probably justifies a canal 12 ft. deep.

"Second.—Barges on the lakes, canals and near sea coasts; ocean steamers for distant sea coasts and foreign trade. This method avoids all transfer in Buffalo and a large part of it in New York. It gives fairly cheap transport on the lakes, canals and along the sea coasts, but it is subject to heavy costs for transfer in New York on a part of the traffic. It probably requires a canal 16 to 18 ft. deep to make it most economical."

Now, in reference to these two alternatives, the writer is unable to see why the first will not give in a reasonable and moderate degree all the advantages of the second. By a 12-ft. barge-canal, all transfer at Buffalo may be avoided, and so can part of it in New York, as barges which will be thoroughly safe on the lakes and able to go to nearby seacoast points can be built to navigate such a canal. It is believed that the amount of freight, directly tributary to a canal, going to or emanating from sea coast points beyond New York would not be very great, and the thing to be considered is the freight going to or starting from New York harbor.

The only disadvantage of the first alternative would be the heavy costs of transfer at Buffalo, and the delays caused by transfer. It is practically certain that these disadvantages are largely over-rated by the author, and that they will exist as well for the second alternative as for the first, for the following reasons:

Mr. Symons. The second alternative would require lines of comparatively small motorless barges on the lakes to run in opposition to the great lake freight carriers of the present and future. Now, it is a fact past dispute that these large lake freighters furnish the cheapest deep, wide-water transportation known, and cheaper, particularly, on the long runs to Duluth and Chicago, than the barges proposed by the author. Also, that there will always be an enormous business on the lakes in iron ore, coal, etc., which will have no reference to a ship-canal, and which would be confined entirely to the lakes, probably twice or thrice the magnitude of the business between the lakes and the ocean, and practically all of which would be carried on these great lake freighters. Therefore, on the lakes there will always be a large fleet of these great freighters looking for business, and they will do it, and if the 18-ft. canal were built the effect would be the same as with a 12-ft. canal; the products of the Northwest would be brought to lower-lake ports in the lake ships and there be transferred to barges, and these barges would be taken through the canal to New York.

The small canal of the present time enables fleets of steel canal boats to run to Cleveland, and ordinary wooden boats to Erie. A canal accommodating boats of five or six times the capacity would surely enable this traffic to be extended to practically as great an extent as would the suggested 18-ft. canal.

The smaller barge-canal, by the Erie Canal route, would have the double advantage over a larger barge-canal, by way of Lake Ontario, in that it would cost much less, and that the barges could be built much lighter and cheaper, plying as they ordinarily would only on the canal and river. There is another practical and far-reaching advantage in adopting a smaller over a larger size canal which should not be overlooked, and this is the comparative ease and inexpensiveness with which it can be extended into various portions of the country adjoining the lakes. It is safe to assume that an 18-ft. canal will cost at least double that of a 12-ft. canal, mile for mile, and that in some instances a 12-ft. canal would be practicable while an 18-ft. one would not. It is quite reasonable to believe that in the future a 12-ft. canal might be built to connect Lake Erie with the Ohio River at Pittsburg or some point further down; that the southern peninsula of Michigan might be crossed by such a canal, giving with the proposed Erie route barge-canal an almost straight line between Chicago and Albany, and that many other canals might be extended into the lake States and to the Mississippi River system, in and along which 1 200 to 1 500-ton barges could be loaded and taken directly to New York and *vice versa*.

It is much less reasonable to believe that these canals would be built to a depth of 18 ft. at double or more than double the expense, and with very little additional advantages.

The third alternative includes really two alternatives:

Mr. Symons.

First.—A ship-canal suitable in size and capacity for the vessels of the lakes to ply between the lakes and the sea, and

Second.—A ship-canal and consequential improvements suited for deep-sea vessels.

These two propositions are quite distinct, the first involving a cost for a canal of approximately \$200 000 000, and the second involving a cost for a canal and deepening lake and interlake channels and harbors of probably \$400 000 000, and neither proposition is believed to be worthy of serious consideration for reasons set forth in the report.

The author does not quote correctly in the table, page 274, giving the transfer charges at Buffalo and New York. He states that "according to Major Symons" the transfer charge at Buffalo is 1.16 cents per bushel, and in New York 1.50 cents per bushel. The figures should be: Buffalo, 1.30 cents, and New York, 1.27 cents. The charge at Buffalo was reduced in 1897 to 1.27 cents.

The transfer charge at Buffalo is made up of three items: shoveling grain to the elevator legs, elevating and storage and trimming. The shoveling charge was \$3.50 per thousand bushels for the years 1895 and 1896, \$3.25 per thousand bushels for the year 1897, and for the year 1898 it has been reduced to \$2.95 per thousand bushels, and there are indications that it may be still further reduced. Indeed, the cost of transfer in all items may be materially reduced this year.

The minimum cost of transferring 100 000 bushels of grain at Buffalo and at New York has been about \$1 275 at each place. A statement that the cost of transferring 100 000 bushels of grain from cars to ships at Philadelphia, Baltimore and Newport News is about \$275, or a little more than $\frac{1}{4}$ of a cent per bushel has been made. If this be true and grain can be transferred from cars to vessels for this cost or double this cost, it robs the author's contention and estimates of their principal remaining points, and emphasizes the advantages of the small barge-canal.

If the barge-canal be constructed, combinations of lake and canal carriers can and probably will be formed which will control their own transfer agencies, and reduce the rates of transfer to something like the cost of similar service at Philadelphia, Baltimore and Newport News, and bring back to New York the grain trade it has lost.

There are several other alternatives beside those mentioned in the paper, such as the construction of a ship canal to Lake Ontario from Lake Erie, and transferring to a smaller canal at some Ontario Lake port, as one near Rochester, at Great Sodus Bay or Oswego; or to still further extend the ship-canal to Oneida Lake and make the port of transfer on this body of water. Conditions can be conjured up and arguments made in favor of any or all these propositions.

Mr. Symons. The writer still believes that the early builders of the Erie Canal selected the best general route for a great commercial waterway between Lake Erie and the Hudson, and that to build a barge-canal along the Erie Canal route, with such modifications and of about the size and capacity mentioned in the report, would be the best thing for the whole country tributary to the Great Lakes, east and west. If everybody interested would pull together this end could be attained. There are strong business and political reasons for retaining an established highway; improving, enlarging, cheapening and maintaining an established system of doing business, rather than building a new waterway, and attempting to establish a new system and order of things. The first should be adopted unless the superiority of the second can be most clearly established.

Mr. Wisner. GEO. Y. WISNER, M. Am. Soc. C. E.—The factors in the problem, which the author has discussed in his very interesting paper, must remain largely unknown until the cost of improving the lake waterways and of constructing canals of various depths from the lakes to the Atlantic has been determined, and until the type of vessel best adapted for such traffic, its cost and annual expense account have been definitely settled. No satisfactory discussion of this question can be made until there is known, approximately, the cost of transportation from Chicago and Duluth to the seaboard, in different types of vessels, through channels of which the cost is known for the depth required. Until these data are known, the advocates of any particular route or type of canal can make assumptions, which cannot be disproved, on which strong arguments may be based in favor of its adoption.

The development of new commerce, arising from the decrease in cost of transportation, is the most important feature of this problem, and any solution which does not allow for such development may result in a useless waste of public funds. In other words, to obtain the maximum benefit from future improvements, the magnitude of our waterways must be such as to stimulate commerce and manufactures to the fullest extent, and to care for the resulting increase of traffic at a minimum rate per ton-mile.

To build a type of canal adapted only to present needs, as has been suggested, with the expectation that the increase of future commerce may require the construction of a waterway of much larger proportions, would not only be a waste of first cost of construction, but also of the amount which would be required for increased cost of right of way, due to valuable vested rights along the route where the canal would have to be constructed. Possibly, under such conditions, an entirely new route would have to be developed, the removal of structures and the enlargement of cross-section interfering with traffic to such an extent as to prohibit any such improvement.

If a 12-ft. canal will not be suitable for handling the future commerce of the West and Northwest, the people of to-day have no right to entail a bonded indebtedness on the next generation for a structure for which they will have no use. Mr. Wisner.

As long as the minimum cost of transportation is secured, the question whether the products of the West and Northwest are to have an outlet to foreign markets through New York, or by way of the Gulf of Mexico, does not concern the general Government.

New York State built and maintained the Erie Canal for the purpose of securing the benefits arising from domestic and foreign trade through the State, and cannot afford to lose the supremacy thus gained by allowing the control of her canals to pass into other hands, neither can the general Government afford to expend millions on such water routes, unless best adapted for developing the commerce of the country.

Legislation in Congress, thus far, has been for estimates of the cost of waterways of sufficient capacity to transport the tonnage of the lakes to the sea, but there are grave doubts as to whether a canal can be economically constructed on the present Erie Canal right-of-way of such cross-section as to allow of the rapid movement of such vessels. A retrograde movement, as to the character of the future steamship on the lakes, cannot meet with any consideration by shippers, and the question, therefore, practically becomes: Would a ship-canal be preferable to a barge-canal with transfers at Buffalo?

It is an established fact that the large modern steamship can carry freight with profit for a rate less than the cost of transport on the older type of small vessels, which fact has led to strong complaints on the part of ship-owners that the improvement of waterways by the general Government results in injury to the owners of small vessels. Hence, whatever the depth fixed for canals and waterways in the future, the limits should be definitely settled at as early a date as possible, and all tentative plans strictly prohibited.

Major Symons, in his recent able report on a ship-canal from the Great Lakes to the Hudson River, arrives at the conclusion, that, with steamers of 16-ft. and 20-ft. draught in a ship-canal of 24 ft. depth, the cost to transport a bushel of wheat from Chicago to New York would be respectively 4.18 cents and 3.65 cents. The author, with exactly the same data, shows that these amounts should be only 2.46 cents and 2.20 cents; and, in doing so, finds that the cost of transport between Buffalo and New York would be over 50% greater than it is between Chicago and Buffalo, when the actual time of passage would be less. If the author is correct in his analysis, the actual cost of transport of a bushel of wheat from Chicago to New York would be less than 1.8 cents; and, in fact, with a properly constructed modern canal, it is equally easy to show that the cost should not exceed 1.5

Mr. Wisner. cents; but the only known factor in the whole question being the present cost of transportation between Chicago and Buffalo, and the time from Buffalo to New York being less than for the lake trip, it is fair to infer that the cost for the entire trip would be less than twice that of present cost to Buffalo.

Considering the present condition of the lake waterways, and that the construction of a ship-canal presupposes the improvement and regulation of the lake channels to correspond in depth with whatever canal section may be adopted, there are good reasons to believe that the time estimated for making the through trip, and consequently the cost per ton-mile, will be much less than given in the paper.

The author is mistaken in estimating the motive power required for a steamer in a canal as only one thirty-fourth that required by the same vessel for an economical speed on the open lake. In a canal constructed in accordance with the requirements of large traffic and rapid transportation, the speed that could be economically maintained would depend on the relative cross-sections of the ship and canal, and the amount of motive power required in a canal would be many times more than that mentioned.

The fact that large steamers can carry freight on the lakes at a much lower rate than small vessels, and that barges of only 10-ft. draught cannot safely navigate the lakes during the stormy season without great loss of time, will necessitate the transfer at Buffalo of a large amount of through freight in case the barge-canal project should be adopted.

In order, therefore, that such a route should be free from any objection arising from a monopoly of canal transportation, it will be necessary for each line of barges on the canal to control a steamship line on the lakes, so as to make through bills of lading between the lake ports and the seaboard. Without such arrangement, it is doubtful whether the improved Erie Canal would carry a ton more freight annually than is transported over that route under present conditions. That the proposed water route may accomplish the purposes desired, all transportation lines must be able to reach the freight and manufacturing centers with equal facility, and there are grave doubts whether this can be secured, except by a through waterway from the lake cities to the seaboard, and, if necessary, to foreign ports.

Mr. Le Conte.

L. J. LE CONTE, M. Am. Soc. C. E. —The lake coast line, beginning at Pigeon River, and extending easterly along the American shore, including both sides of Lake Michigan, and continuing to Oswego, N. Y., comprises approximately 2 240 miles, or is greater in extent than the entire Atlantic sea-coast of the United States.

The average citizen does not realize that on the chain of lakes the total annual tonnage cleared from all the collection districts, exclusive of Canadian bottoms, is fairly estimated to be 45 000 000 tons, carried

by 60 000 vessels. This prodigious volume of land-locked commerce is Mr. Le Conte. demanding an outlet on the Atlantic Coast. History shows that whenever such a great public necessity arises, an intelligent community will always provide a proper remedy, regardless of adverse pressure.

The great question then becomes: What is the most practicable solution of the problem presented? The writer thinks that the splendid fleet of steamers now navigating the chain of lakes cannot be excelled as freight carriers by any ocean steamers of like draft—say 20 ft. To accommodate the entire lake fleet of carriers he would therefore advocate a 24-ft. canal direct to New York City and the Atlantic coast. Exports could preferably be transferred at New York to mammoth deep-sea carriers of 30-ft. load-draft destined for European ports; these 30-ft. carriers not being able to compete with the speedy lake fleet, even on a deep-water canal, disregarding the extra cost and practicability.

Above all, the 24-ft. canal should be wide enough, because in busy seasons width is far more important to free navigation than extra depth. The author's estimate of possible speed—4 miles per hour—is too low, there being no good reasons for doubting the possibility of obtaining a speed of 7 to 8 miles per hour on a commodious 24-ft. canal. Many of the smaller tidal rivers are practically ship-canal, and several are now safely navigated at a speed of 8 miles per hour. The wash of the banks has not been a matter of great moment, and in fresh waters this difficulty can be controlled by natural growths of various kinds.

Calculations relating to the financial details of this great problem are all misleading and of little weight, for the reason that they fail to touch upon the largest and most important factor in which the public is interested—the great indirect benefits which always accrue to the commonwealth by reason of the great expansion of the field of opportunities for commercial development. The Holland canals show conclusively that the public benefits derived through the enlargement of the smaller canals are always in excess of the most sanguine estimates made by experienced men. The lowering of freight rates swells the volume of the annual tonnage movement to such an extent as to make an extravagant estimate seem conservative when compared with the results obtained by subsequent development. The past history of the Suez Canal or of the Sault Ste. Marie Canal controverts any doubt in this regard, and a study of the subject will throw a flood of light on all such predictions.

L. F. VERNON-HARCOURT, Esq.—The conditions of the transport of wheat from the Northwestern States of America to Europe by water are peculiar, for the transit has to be effected first on the Great Lakes, then by canal and river from Buffalo to Albany and New York, and,

Mr. Vernon-Harcourt.

Mr. Vernon- lastly, across the ocean. Transport by water for long distances is so
Harcourt. economical in comparison with conveyance by railway, that the wheat from Manitoba and the west of Canada, which is carried from Winnipeg to Lake Superior, is largely diverted to the lake navigation at Fort William and Port Arthur, in spite of the necessity for transshipment, so that the doubling of the line of the Canadian Pacific Railway between Winnipeg and Port Arthur is in contemplation to provide for the heavy traffic eastward in the autumn; whereas to the east of Port Arthur, the single line amply suffices. The connecting canals providing navigable waterways between the lakes, and to deep water in the St. Lawrence near Montreal, have already been given a depth of 14 ft.; and on the completion of the new Soulanges Canal in a year or two, there will be throughout an available navigable depth of 14 ft. from Lake Superior to Montreal, enabling the wheat from the western provinces to be conveyed by water in large barges from Fort William or Port Arthur to Montreal without transshipment.

Transport by water from Chicago to New York and the eastern seaboard is at present conducted at a serious disadvantage, owing to the available depth of only 7 ft. in the Erie Canal, which is being slowly increased to 9 ft.; and this waterway will contrast very unfavorably with the Canadian waterways connecting Lake Superior with Montreal as soon as the Soulanges Canal is opened for traffic. The traffic, indeed, on the Erie Canal is much greater than that which has as yet passed through the Welland and St. Lawrence canals, with an available depth of 9 ft.; but the traffic on the Erie Canal has exhibited a remarkable diminution in the last quarter of a century, whereas the traffic through the Welland Canal has increased slightly during the same period, and the through traffic to Montreal, though comparatively small, has augmented greatly since 1881. It therefore appears that while there is a good prospect of a great increase of traffic by water from Lake Superior to Montreal when an available depth of 14 ft. shall have been secured throughout, the railways will probably more and more draw away the traffic by water between Buffalo and New York, unless an improved waterway is provided between Lake Erie and the Hudson River.

Thos. W. Symons, M. Am. Soc. C. E., in a report from which the author seems to have derived some valuable statistics, has proposed the enlargement of the Erie Canal, affording an available depth of 12 ft., and rendering it suitable for barges of 1 500 tons. Considering, however, that the Canadian government has deemed it necessary to provide a greater depth than 12 ft. for the traffic by water from the Great Lakes, and that the Erie Canal formerly possessed a very large traffic, it seems that a depth of 12 ft. would not be sufficient to afford access for a suitable class of large barges, or to compete effectually with the railways and regain the lost traffic. Some of the cities

on the Great Lakes have the ambition to become seaports, which would necessitate the construction of ship-canals with an available depth of about 28 ft. from Oswego to Albany, in place of the Erie Canal, and between Lake Erie and Lake Ontario, and also the further enlargement of the St. Clair and Sault Ste. Marie canals and the deepening of the lake harbors; but the great cost of works of this magnitude and the expenditure involved in an ocean-going vessel having to navigate a great length of canal at a slow speed, appear to render this solution of the problem of through transport inexpedient on economical grounds, notwithstanding the saving effected by dispensing with transshipment. The proper expedient appears to be the adoption of a middle course, by the construction of connecting canals of sufficient depth to accommodate large barges suited for traversing the lakes, for which the Sault Ste. Marie and St. Clair canals are already adapted, and thereby enabling bulky produce to be conveyed economically by water from the furthest points of Lake Michigan and Lake Superior to New York without transshipment. This arrangement, though necessitating transshipment into ocean-going steamers at New York for cargoes destined for Europe, enables New York and the cities of the eastern seaboard to be supplied direct from the West; it enables the tractive force to be adapted to the portion of the route traversed, thereby avoiding the waste in traction resulting from the passage of an ocean-going steamer through a canal; and, according to Table No. 1, it affords the most economical method of transportation between Chicago and Liverpool. If such a waterway, with an available depth of 18 ft., is constructed, there is every prospect that a large traffic would again be attracted to the water route, and that the cost of transport between the Great Lakes and New York would be materially reduced.

T. C. KEEFER, Past-President, Am. Soc. C. E. —The title which the author has given to his valuable paper is in connection with the consideration of the most economic canal between the Great Lakes and the Atlantic; where (as in the case of the Suez Canal) the economic depth should be that which covers all the conditions of the traffic and the route. In the writer's judgment there is no other route where the greatest practicable depth is more needed; and that depth, therefore, should be the economic one, and be determined by the ultimate depth attained in the river connections between Lakes Erie and Superior.

There are half a dozen cities on the lakes above Niagara, which have already attained a population, and a commercial and manufacturing position, fitting them to become seaports, which, as the author remarks, they desire to be. They have the largest tonnage, and some the highest average per ton on the continent; and of necessity build their own vessels, of the best material and construction, from steel manufactured upon the spot. These steamers are increasing their

Mr. Vernon-Harcourt.

Mr. Keefer.

Mr. Keefer. dimensions as rapidly as increased depth is given to the rivers connecting the lakes. The greater part of this land-locked fleet could readily be adapted to any service if released from its winter imprisonment; and a most important consideration for its builders is that the yards which have turned out such steel vessels as are now found upon Lake Erie, can successfully compete with the world, whenever they are enabled to "deliver the goods."

The author estimates that a saving in transportation charges of 4.61 cents per bushel of wheat would follow the construction of a canal 28 ft. in depth, which is the ultimate depth recommended by the United States International Commission of 1895. The inference to be drawn from the report of that commission is that all structures should provide for this depth, and the rest of the canal be governed, at first, by the depth attained in the lake-connecting rivers.

A saving of 4.61 cents per bushel on the grain and products of grain received at Atlantic ports north of the Chesapeake alone would equal the interest on a sum of over \$300 000 000. Other agricultural products, provisions, cured meats, cheese, butter and lard, would share equally in the reduced rates, and, therefore, be enhanced in value, while the export of coal, coke, ore, iron and steel and their manufactures (especially ocean steamers) would, most of them, only be possible through an adequate ship-canal.

The author observes at the outset of his paper that the Northwestern States are vitally interested in reducing freight rates to Europe even more so than to home markets, since the home price of the principal exports is determined by that in the foreign markets, less the cost of reaching them. This truism is at the bottom of the demand for a ship-canal by the Northwestern States, for, if the author's admitted saving of 4 cents, odd, per bushel is applied to all their surplus, over the producers' wants (amounting to thousands of millions of bushels of grain, together with that upon other agricultural products), the annual gain to these States would not be much short of, if it did not exceed, \$100 000 000. Apart from agricultural products, the gain to these Northwestern States and their lake cities in opening new markets for their other exports, cannot be estimated, but it is evident there is an aggregate of economy, in sight, which warrants the effort made to obtain it.

Damage, or depreciation in transshipment, is an additional element of economy (not referred to by the author) in favor of a ship-canal, to which it is more difficult to attach a money value, because it is dependent upon the cargo. On grain it may be ignored, but not on the products of grain. On perishable products the facilities afforded for cold storage in the large through-carrier would be important as compared with a transfer route, while on all package freight in either direction there would be a distinct money gain (besides that of loss of

time and cost in handling), when the goods are delivered in the same Mr. Keefer condition as when shipped.

The only possible competitor with the best canal between the lakes and the Atlantic is the railway of the future. The railway has the advantage of having no closed season, and of penetrating the interior so as to cut off supplies to the water route, as well as of being able to deliver them at their inland destination. It has already "cut its rates in two" more than once; and what the future railway will do, with improved grades and alignment, heavier rails, bridges, train-loads and higher speed, remains to be seen. Enough is foreshadowed to show that no canals but those of the largest capacity can compete with railways in economy, while only such canals as will pass the ocean carriers will surpass them on the question of transshipment, because the railway, whatever its capabilities, is not amphibious.

The author in his paper deals wholly with routes lying within New York State, and refers to "the enormous expense required" for a 28-ft. canal on those routes. The expense would no doubt be enormous, although it might, if successful, be warranted by the results, but the writer believes the length of a canal on a Buffalo and Albany route, and the increased lockage of an Oswego-Mohawk route, will increase the time of transit, and contingencies of interruption, so as to seriously affect the efficiency of either route in competition with railways.

The question of route was left open by the United States International Commission of 1895, to await the results of surveys and estimates. The Canadian section of that Commission had no mandate from their own government except to respond to the invitation of the Government at Washington, by assisting the United States Commissioners in their investigation, which it was assumed would cover all possible routes between Lake Erie and the Hudson River. It is supposed that the United States International Commission of 1895 was the outcome of the International Association which met in Cleveland, and that it was made international because the Northwestern States wanted direct communication with Europe, through the St. Lawrence, as well as the best connection with their great home market in New York and New England, and believed this last might be possible, under the best conditions, upon an international route *via* Lake Champlain.

The Canadian adjunct to this Commission, in its final report to the Government of Canada, says:

"The supreme value to the Northwestern States, as well as to the Canadian prairies, of an international route for deeper waterways is that it will combine the shortest route to the Canadian seaboard, Europe and Lake Champlain with the broadest, deepest and most speedily navigated waters, and, therefore, the quickest route between the heart of this northern Continent and New York."

Mr. Keefe. "The probable route of such an international work will be one by which all the new large canals required between Lake Erie and the Hudson River will be located along the northern and eastern borders of the State of New York, with the single exception of the one between the River St. Lawrence and Lake Champlain, which is the only one necessarily within Canadian territory."

"There is only one international route possible, which is that *via* the St. Lawrence River and Lake Champlain, which is also one which permits the extension of this deep water system to Montreal and thus to Europe on the shortest possible line. This fact, together with the consideration that the St. Lawrence-Champlain route gives the greatest extent of wide and deep water, the least mileage of artificial channel, and the minimum of lockage possible, has given rise to this international Commission."

Mr. Burr. W. H. BURR, M. Am. Soc. C. E.—The paper is practically a discussion of the report made by Major Thomas W. Symons to Gen. John M. Wilson, Chief of Engineers, U. S. A., on a preliminary examination for a ship canal between the Great Lakes and the navigable waters of the Hudson River.

That report took the shape of a recommendation by Major Symons in favor of a 1 500-ton barge-canal. This report and its discussion must necessarily raise the general question of the economic transportation of grain from the fields of production in the West to ports of export, as well as to the great domestic markets of the eastern portion of the country, which have been created by the development of industrial centers. In the early days of the transportation of surplus grain from the West to seaports, and to the eastern domestic markets, the Erie Canal played a controlling part. Although it is scarcely more than thirty years ago that the railroads first began to transport grain from the western fields to eastern points, they have now taken nearly all of that carrying business. This is so great a revolution in the business between the West and the East, and the conditions which have made it possible have caused such other radical changes in the fields of transportation, that it has become imperative to examine all the features of the situation in order to determine in what direction future developments of grain carriage may be made. The most serious aspect of this condition of things for the Port of New York arises from the fact that these changes in transportation have resulted in the diversion of a portion of its commerce, already large and constantly becoming larger, to other ports. During the past few years there have been a number of active agitations of a public and semi-public character, having for their common object, the amelioration of the conditions now burdening the transfer of freight, chiefly between the Great Lakes and tide water of the Hudson River. These agitations and the examinations resulting from them have in the main led to a consideration of three routes; one, constituting essentially an enlargement and improvement of the Erie Canal, together

with such rectification of its alignment and levels as might seem advisable; the second, being known as the Oswego route, involving an enlarged or possibly a ship-canal between Lake Erie and Lake Ontario and the improvement of the Oswego River, together with such other constructions and improvements as would form a suitable junction with the Erie Canal at or near Rome, from which point eastwardly the route of the present Erie Canal or the canalizing of the Mohawk River would be adopted; while the third is known as the St. Lawrence-Champlain route, involving the construction of a canal from a suitable point on the St. Lawrence River to Lake Champlain, and from thence southward to the Hudson River.

The two former lie wholly in United States territory, while the latter lies partly within the limits of Canada, and is a much longer line than either of the other two. Major Symons properly decides against any serious consideration of the St. Lawrence-Champlain route. He also concludes that a ship-canal sufficiently large, even to accommodate the present lake freight steamships, is not worthy of being considered by the United States Government, whether the entire Erie Canal route be adopted or whether the Oswego route shall be selected. His investigations lead him to believe that the most economical transportation of freight, chiefly of grain, can be secured by the construction of a barge-canal, practically along the line of the present Erie Canal, of sufficient capacity to float 1 500-ton barges, which would probably be towed in fleets of four. Major Symons' treatment of the question is the first systematic engineering study of the problem, and yet there may be some diversity of opinion as to the strict accuracy of his conclusions. The author is of opinion that too much weight has been given to the effect of such time as the barges or steamships, in the case of a ship-canal, would spend in Buffalo Harbor. Buffalo, however, is and always has been a point of great importance to all freight which may be transported between the Great Lakes and tide-water of the Hudson, and whether too much or too little importance has been attached to that matter will not greatly affect the final solution of the problem.

The present condition of the matter arises largely, if not entirely, from the fact that the railroad companies, whose lines run from the grain-producing fields of the West to the export points, have been tireless in the improvement of their transportation facilities. They have given to their roadbed and to their equipment every degree of excellence to which engineering science or experience can attain. In addition to this they have been equally tireless in the improvement of their organizations, so that at the present time their freight rates are probably as low as even the present advanced state of civil engineering resources and business administration will permit. On the other hand, the Erie Canal is practically in the same condition in which it

Mr. Burr. was forty years ago, in spite of the fact that steam power is now employed on it; hence the question arises: "Shall the improvement now take the form of a barge-canal or a ship-canal?"

As an illustration of the reduction of freight rates by rail, which has been reached by the extraordinary improvements in rail transportation during the past twenty-five years, the following table is also taken from Major Symons' report, page 69:

AVERAGE FREIGHT CHARGES PER BUSHEL.

Year.	By all rail, Chicago to New York.	Canal, Buffalo to New York, including tolls and trimming at Buffalo and shoveling at New York.	Canal tolls.
	Cents.	Cents.	Cents.
1874.....	28.7	10.11	3.10
1875.....	24.1	8.01	2.07
1876.....	16.5	6.08	2.07
1877.....	20.3	7.52	1.03
1878.....	17.7	6.08	1.03
1879.....	17.3	6.86	1.03
1880.....	19.9	6.51	1.03
1881.....	14.4	4.75	1.03
1882.....	14.6	5.39	1.03
1883.....	16.5	4.96	Toll
1884.....	13.12	4.13	abolished.
1885.....	14	3.85	
1886.....	16.5	5.03	
1887.....	15.74	4.38	
1888.....	14.5	3.37	
1889.....	15	4.38	
1890.....	14.31	3.89	
1891.....	15	3.58	
1892.....	14.23	3.42	
1893.....	14.7	4.65	
1894.....	12.88	3.17	
1895.....	10	2.19	
1896.....	12	3.75	

Major Symons' investigations show conclusively that a barge-canal is best qualified to meet transportation demands as they now exist and that the Erie Canal, enlarged on a rectified alignment so as to float the barges advocated by him, would be such a waterway. Obviously the final solution of the question cannot be reached until complete and accurate surveys of the entire line between Buffalo and the Hudson River are completed. It is much to be desired that the operations of the present Deep Waterways Commission may be so directed as to complete this particular work at as early a date as possible. With such data as that survey would afford, it is reasonable to suppose that a sufficiently close estimate of costs could be made, to determine the most economic section of waterway to accomplish the purposes which the present conditions of transportation demand. There is a balance of charges to be determined between the decreased cost of a restricted waterway and the increased costs of transportation on it. If the section

of the waterway cost nothing, obviously the most economical channel Mr. Burr. would be one of practically indefinite width and depth, but the interest on the cost of a great section will at some point begin to overbalance the small cost of transportation only.

The economic disadvantage of attempting to sail expensive craft at a low speed over a restricted waterway, and the business wisdom of fitting the vessel to the water which it must navigate is well illustrated by one of Major Symons' tables, found on page 52 of his report, and here reproduced. The table gives the estimated value per ton of carrying capacity of the various grades of vessels indicated:

Steel ocean steamers.....	\$60	to \$70
Steel lake steamers	35	" 50
Erie canal boats, plain.....	9	" 12
Erie canal boats, in fleets, with steamer.....	12	" 20
Large 1 500-ton canal barges:		
Plain, about	8	
In fleets, with steamer.....	10	" 11
Ohio and Mississippi coal boats.....	0.50	
Ohio and Mississippi coal barges.	2	" 2. 20

The interest charge on steel ocean steamers would plainly be very high for the slow speed of a canal. The same observation applies largely to the steel lake steamers, while it would obviously be a small charge for the 1 500-ton barges.

Major Symons estimates that the rate per bushel of grain from Chicago to New York on the 1 500-ton barge-canal, with present transfer charges at Buffalo, should be about 3.6 cents per bushel, whereas the present rate by lake and canal is about 2 cents more per bushel. If one-half only of this saving were applied to the grain actually consumed in and about the Port of New York, which is probably not far from 33 000 000 bushels per annum, the saving on that one item would be \$330 000 per year. It is probably impossible to compute accurately the aggregate saving on all classes of domestic productions affected by the decreased rates of transportation, but the consideration of this one item shows that it would be a very large sum. That amount of saving per bushel of grain for export would be sufficient to turn the great stream of the export wheat trade through the Port of New York, and arrest the decay of foreign commerce, which is now going on in that port, and regain for it its former degree of supremacy.

JOSEPH MAYER, M. Am. Soc. C. E.—The author's first reading of Mr. Mayer. Major Symons' report produced a strong impression that he had solved the problem of the best size of canal between Buffalo and New York, and he has observed that the same impression was produced on others; but a closer scrutiny of Major Symons' figures convinced the author that his arguments are inconclusive and that a different size of canal could

Mr. Mayer. be defended successfully, even if the facts on which his arguments are based are assumed to be correct. A study of the question convinced the author that the accessible facts are insufficient to prove conclusively the superiority of any size of canal. The author thinks that a careful reading of the discussion will produce the same impression on most students, and he therefore believes that the paper and the discussion have accomplished the purpose intended, which was to produce a suspension of judgment, which is the best state of mind for forming a correct opinion of the merits of the different sizes of canals when the missing facts become available. It has been stated in the discussion that the benefit produced by the cheapening of the cost of transportation between the West and Europe would ultimately accrue to Europe and not to America. This statement is based on the comparison of this improvement with an improved process of cultivation. The difference between this improvement of the means of transport and an improvement in the process of cultivation is in the fact that this saving in cost of transport helps only a part of the producers supplying the European market, and not all, or even a majority, of them. This is the reason why the argument brought forward in favor of the view that Europe and not America would ultimately derive most benefit from the canal does not apply to this case.

The effect of the reduction in the cost of transport between the West and Europe would undoubtedly be an equal diminution of the difference between the European and western price of exported or imported produce.

If the exports are considered, the saving would accrue to the western farmer unless the canal had the effect of diminishing the European prices of exported produce.

The European price of wheat, for instance, will gravitate to a point where the European wheat crop and the foreign imports of wheat to Europe equal the consumption. The United States wheat production is about one-quarter of the European consumption. Any reduction of the price of wheat in Europe will reduce the whole supply of Europe, any increase of the price of wheat in America will increase the American production, and therefore the exportable surplus. If, in the absence of evidence to the contrary, it is assumed that a given change in price will produce the same percentage of change in the average annual production in America and in other countries; then a reduction of 4.6 cents per bushel in the cost of transport of wheat would ultimately be divided between Europe and the United States in the proportion of one to three, because this would produce a reduction of 1.15 cents in the European price and a rise of 3.45 cents in the American price. The change in the American price would affect a product amounting to one-fourth of the European consumption; the change in the European price would affect a product amounting to

three-fourths of the European consumption. The supply from America Mr. Mayer would therefore be increased by the same amount as the supply from other sources would be decreased. Various corrections would have to be introduced to make this argument accurately represent the facts, but they would not affect the substantial truth of the inference.

The foregoing demonstrates that the benefit derived from the saving in cost of transportation of wheat between the West and Europe would largely accrue to the producers of the West. They would not only obtain an increase in price of about 3.45 cents per bushel, but would be enabled to supply a larger proportion of the total European demand.

So long as any reduction in the cost of production, or transportation to market, of any produce affects only a small part of the total supply of that produce, the greater part of the saving will accrue to the producer of that part.

In regard to imports of foreign produce, it can be shown, in the same way, that as long as the articles imported and transported through any cheapened methods in this country are only a small part of similar articles produced, the benefit will accrue to the American consumer.

The substance of the paper consists in showing that the cost of transport is very small and the cost of transfer very large; that there is, therefore, more chance of saving in the cost of transfer than in the cost of transport, and, that efforts should be in the former direction.

Engineers are inclined to assume that transfer charges have a definite relation to the cost of doing the work of transfer and to infer that transfer charges would be reduced by a labor-saving change in the method of doing the work. They infer also, from the fact that in other ports transfer charges are much less than in New York and Buffalo, that there is a near prospect of the reduction of charges in these latter places. Experience has shown that New York and Buffalo offer favorable conditions for pooling the business of transfer; that is, for agreeing not to compete, but to fix standard charges and divide either the business or the profits in definite proportion. Under such conditions of monopoly the cost of doing the work has no direct relation to the charge for the same.

Monopolies, if they are intelligently managed, charge what the traffic will bear; if not, they charge what the traffic will not bear, and ruin the business. In the transportation of grain by water from the West to Europe there have been existing for a long time two monopolies, one levying tolls in Buffalo, the other in New York. The traffic will bear a certain total amount of toll at these two places; if one of these tolls is reduced, the other can be increased. These two monopolies could not agree with each other as to the proper share of the practicable toll for each. The sum of their charges has exceeded what the traffic will bear, and the business has therefore been decreasing. As long as the succeeding links of a through transportation

Mr. Mayer. line are not under one and the same management, no link can count upon getting the benefit which can be derived from a reduction in charges and consequent increase in business, since its reduction may be counterbalanced by an increase in the charges of another link. Any link will get all the benefit which can be derived from an increase in its charges, and will suffer only part of the loss due to a decrease in business produced thereby. The public, which desires low transportation charges, is therefore interested in bringing about the consolidation of all the succeeding links of through transportation lines, since this makes it possible to obtain reductions in charges with the aim of profiting by the increase in business thereby produced.

Public policy ought therefore to favor and not to hamper such consolidation. The growth of outside competition to the water transportation between Chicago and New York has decreased the sum of the tolls that can be successfully collected in Buffalo and New York.

The improvement of the Erie Canal will increase this sum again and will be of great benefit to the transfer business in New York and Buffalo, especially if the two monopolies combine and come to a reasonable agreement in regard to the division of the spoils, which will enable them to keep their charges down to what the traffic will bear.

The position of the transportation business, by water, between the West and Europe is about the same as would be that of a great manufactory, the transportation of whose ingoing and outgoing goods to and from the nearest railroad is in the hands of two monopolies, able to fix their charges at their own discretion. No private capitalist would be inclined to spend much money for the improvement and enlargement of such a factory. Under such circumstances the first efforts would be devoted to the breaking up of these monopolies before any further investments would be made in the factory. The public should follow the same policy with its canals.

Before deciding to spend any money on the improvement of the canals, unless this improvement makes transfers superfluous, an investigation should be made of the means by which the excessive transfer charges in New York and Buffalo are maintained, and the conditions under which transfers in New York and Buffalo are conducted should be so changed that the monopolies will be broken up and competitive rates established. It may be necessary for the Government to provide its own transfer facilities, or to rent space for such to parties who will promise to furnish the same in abundant quantity at rates agreed upon beforehand. Unless it is practicable to reduce, not only transfer cost, but transfer charges, to very much lower rates than at present exist, it would be manifestly injudicious to build a canal necessitating transfers. The advocates of such a canal could not use the next few years to better purpose than in accomplishing this result. They may possibly

thereby bring it about that a 12-ft. canal necessitating transfers will become a useful public improvement. It may, however, be found that a large part of the apparently excessive transfer charges is due to conditions which cannot well be removed.

The author still believes that the necessarily remaining transfer charges, and the other costs and disadvantages of transfers are sufficient to justify the additional expense of a larger canal, making it possible to avoid all transfers in Buffalo and a large part of those in New York.

The objection has been raised against an 18-ft. canal that the barges which could pass through it from the lakes and the sea coasts could not do business on the lakes as cheaply as can large steamers. Even if this is true, which is doubtful, considering the present ability of such barges to compete successfully with steamers on the sea coasts and on the lakes, it does not follow that the difference between cost of transportation on the lakes, in such barges and in steamers, is large enough to approach the cost of transfer in Buffalo, which would be necessary to induce transfers there. It has been asserted that Major Symons' report is misquoted in the paper, in regard to transfer charges in Buffalo and New York. The author stated that the average transfer charge in Buffalo is 1.16 cents per bushel.

Major Symons says the transfer charge down is 1.3 cents per bushel, and he assumes for his calculations the transfer charge up 25 cents per ton, or 0.75 cents per bushel, and estimates the business up to be one-third as large as the business down. This gives the average transfer charge up and down $\frac{(3 \times 1.3) + 0.75}{4} = 1.16$ cents per bushel, which is identical with the author's statement of the same.

In regard to the transfer charge in New York, Mayor Symons states on page 104, of his report:

"If wheat is shipped direct through New York, the average transfer charges, including demurrage, extra storage, etc., will amount to 50 cents a ton, or $1\frac{1}{2}$ cents a bushel."

These charges would all be saved if there were no transfer in New York. The author is therefore correct in stating this amount as saved and not 1.275 cents per bushel, which is only part of the saving effected by avoiding transfer in New York.

The author has been charged both with overestimating and underestimating the time required by a vessel to pass through a 24-ft. canal on the Oswego route from Buffalo to New York. He assumed the average speed in the canal to be 4 miles per hour. The average speed of vessels without consorts, allowing for all delays, in the Baltic and North Sea Canal is reported to be 6 miles per hour. The author endeavored to prove by his argument that Major Symons' estimate of the time required for the round trip between Buffalo and New York was excessive. He was therefore on the safe side in assuming

Mr. Mayer. only two-thirds of the speed actually attained, not in single cases under special circumstances, but on an average over a whole season in an existing canal similar to the one considered. It is not the author who is theorizing in this matter and assuming things based on no actual experience, but his opponent who has no actual facts to sustain his assertion. As regards the necessity of a steamer, loaded with grain from Chicago for New York, assuming the existence of a 24-ft. canal, spending days in Buffalo, for recoaling, provisioning and repairing, only astonishment can be expressed that such an assertion should be made.

Referring to the best route for a large canal and the question as to who is to build it, which are closely connected, very little has been said in the paper. The reason for this is the fact that no reliable estimates of cost of canals of different depths on the various routes are available, and to decide for or against any particular route, without such estimate, seems impossible. The problem of providing a ship-canal or a canal for lake-going barges is fundamentally different from the original one of building the Erie Canal. In the latter case the investment was \$5 000 000; in the former it would be over \$100 000 000. The original Erie Canal caused a saving of about 20 cents a ton-mile in the previous cost of transportation; a ship-canal will cause a saving of about 0.2 cents a ton-mile over the present cost of transportation. The investment will be twenty times as large; the saving in the cost of transporting one ton will be only $\frac{1}{100}$ of what it was when the original Erie Canal was built. It is evident that the larger canal would have to supply transportation to a large part of the United States to be a paying investment, and the resources of all interested parties will be required to carry the enterprise through. The local business would be small in comparison with the through business, and the interest of the State of New York in its completion will be small in comparison with the combined interests of the Western States and the remainder of the East. The effort of the State of New York to keep control of this enterprise is, in the author's opinion, quixotic and will delay or kill the whole scheme. If the United States is to build the canal it will be so built as to best accommodate the through business.

The site of the present Erie Canal does not seem to be fitted for a large canal; there remain, therefore, only the Oswego route and the Lake Champlain route, of which the former, as by far the shorter, is preferable, unless the cost, which is at present unknown, is very much against it.

The surveys and estimates now being made and the completion of the Canadian 14-ft. canals to Montreal will furnish much new information on this question, and will probably permit of the formation of a well-founded opinion on the best size of canal from the West to the sea coast.